THE FEASIBILITY OF A DECISION SUPPORT SYSTEM FOR THE DETERMINATION OF SOURCE SELECTION EVALUATION CRITERIA

THESIS

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of the Air Force Institute of Technology
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Preface

I was prompted to pursue a topic in the area of Source Selection by a personal letter from Air Vice Marshal A.E. Heggen, Chief of Air Force Materiel RAAF, whose welcomed guidance directed my efforts into an interesting and rewarding area. For that timely assistance I am indeed grateful.

I would like to acknowledge the very valuable assistance and guidance received during this research from Dr. William C. Pursch, Head, Department of Contracting Management, Air Force Institute of Technology, who, as thesis chairman, was most patient, understanding, and thoroughly professional in his able supervision of the program.

Thanks are also due to Mr. James Helmig, Chief, ASD Source Selection Division for his personal advice and very generous assistance in obtaining approval for and providing access to the data used for the research.

Undoubtedly, the singularly most important assistant I was fortunate to have, always available on call, was my wife Loretta whose inexhaustible understanding and patience throughout the entire effort has no equal.

Finally, my children, Cameron (7), Andrea (4), Michelle (2), and Philip (11 months) deserve recognition for their unswerving support and enduring patience with a father

who was not able to give them anywhere near the amount of attention they need and deserve at this stage of their lives.

Roxley K. McLennan.

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Abstract

This thesis

This exploratory research aimed to assess the feasibility of creating a decision support system (DSS) to aid ~~the~~ a program manager in determining the evaluation criteria to be used in a Source Selection. The topic was approached in general terms with a review of the DOD and USAF regulations and other literature pertaining to source selection evaluation criteria, and also a brief review of decision making processes and a DSS ~~decision support system~~ framework.

A dataset of 81 previous source selection plans from Air Force Systems Command, Aeronautical Systems Div~~ision~~ was examined with the aid of a commercially available microcomputer-based database management system to see whether previous experience of selection of evaluation criteria could be incorporated into a DSS. A heuristic method~~ology~~ was developed which can provide an indication to the program manager of the criteria areas he should consider for use in his source selection, based on ~~the~~ historical data. It involves describing the system under procurement in terms of specific attributes of the system, and using the associations observed between those attributes and criteria within the historical dataset to predict the likely criteria for the new system.

The research presented only the general basis for a DSS and further research is required to establish the validity of the methodology and implement a DSS in any particular operational situation.

THE FEASIBILITY OF A DECISION SUPPORT SYSTEM FOR THE DETERMINATION OF SOURCE SELECTION EVALUATION CRITERIA

I. Research Proposal

Introduction

Air Force Logistics Doctrine, AFM 2-18, divides the Logistics System into the four interdependent subsystems of Requirements Determination, Acquisition, Distribution, and Maintenance. The acquisition subsystem is often described (2:9-2) in terms of an acquisition cycle consisting of the folowing phases:

a. need identification, review and validation,

b. conceptualization,

c. demonstration and validation,

d. engineering development, and

e. deployment (which leads back to further need identification).

The demonstration and validation phase -

> includes extensive studies and analysis of alternatives [of proposed systems] and may include development of prototypes or other hardware with subsequent test and evaluation of the products. Competing contractors respond to the [Air Force's] request for proposal (RFP), detailing their approach, costs, schedule, management plans, additional options and various other information. The Air Force, through a process called source selection, narrows the competition to the most promising options and signs contracts for design development, prototype development, or both [2:183].

The aims of the source selection process are detailed in Department of Defense Directive (DODD) 4105.62 as follows:

> The prime objectives of the process are to; (a) select the source whose proposal has the highest degree of realism and credibility and whose performance is expected to best meet Government objectives at an affordable cost; (b) assure impartial, equitable, and comprehensive evaluation of competitors' proposals and related capabilities; and (c) maximize efficiency and minimize complexity of solicitation, evaluation and the selection decision [40:2].

The source selection process is managed by a Program Manager (PM) under the direction of a Source Selection Authority. The Source Selection Authority may be as high as the Secretary of Defense for major weapon systems or as low as product division commanders. The selection is carried out by evaluating contractors' offers against standards called Source Selection Criteria, which are detailed in a pre-evaluation prepared Source Selection plan.

The source selection criteria, and the determination of those criteria, is the area of concern for this research effort.

The Problem

Much criticism is levelled at the source selection procedures because of the time involved in completing the process. Turner (36:1) quotes Congressional committee reports which call for the "need to improve practices and reduce delays in the source selection process." Among the

reasons for concern over the time spent in the source selection process is the high cost of the activity. The variable cost, which is a function of time, not only includes the element of the salaries of highly qualified personnel, but also the opportunity cost of the loss of those personnel by the other activities from which they have been drawn, the opportunity cost of delays in introduction of the weapon system, inflation driven price escalations, and so on.

Notwithstanding the objectives of the source selection process discussed previously, and mindful also of the potentially high cost of an inadequate source selection decision, any contraction of the duration of the process through improved efficiency or techniques will result in substantial cost savings and is a topic worthy of pursuit. The problem then, is the high time-dependant cost of the source selection process and the broad aim of this research effort is to reduce the duration of the source selection process consistent with maintaining the quality of the source selection decision.

The Research Question

The standards against which the contractors' proposals are evaluated are contained within the Source Selection Criteria. The validity of the evaluation is entirely dependent on the validity of the criteria since this is the only measure of the worth of each proposal.

Inappropriately selected criteria renders the evaluation procedure invalid before it even starts, and an invalid source selection is not only very costly and time-wasting, but may be catastrophic for the entire project. Thus the selection of the most suitable criteria for a given acquisition is a vital element of the source selection process.

Selection of the most appropriate criteria first involves an indepth study by the program manager of the weapon system characteristics, then an identification of those areas of the production system which will have a significant impact on the success or failure of the project and on the operational value of the weapon system itself.

A complicating factor however, is that the personnel employed on source selections often have little previous source selection experience and may be approaching a difficult task with but a vague sense of direction. Pingel (29:12-13) cites such situations as increasingly common in U.S.Navy acquisition activities, and Aeronautical Systems Division (ASD), Air Force Systems Command, Wright-Patterson AFB, face similar problems (22). Even with the guidance of the several publications described in Section II and the assistance of those personnel with experience that are accessable, some time will be lost by the inexperienced project manager while he "feels his way" and brings his knowledge up to a level which enables him to intelligently

attack the problem. The selection of the evaluation criteria is a particularly difficult job for the inexperienced and a potential source of future problems for the source selection process and the program.

The research question then is: Is a decision support system, designed to aid the project manager in the determination of source selection evaluation criteria, feasible?

Background

The extent of criticism of the source selection process, the high dollar values of modern weapon systems, the relative infancy of the source selection procedures, and the attraction of the source selection activity as an avenue of litigation by unsuccessful offerers are among factors which have led to much research directed toward improving the process.

Turner (36) examined the techniques and methods used by each of the three U.S. Armed Services to "analyse their salient differences [and] to identify and evaluate unique or innovative source selection techniques that could be useful to the other services." Peters (27) evaluated the source selection procedures within the Air Force for major modifications with a view to identifying and correcting problems and "provide an alternative to Source Selection Procedures."

Closer to the topic of this research effort, Helmer and Taylor, in their Conceptual Model for Evaluating Contractor Management During Source Selection (21), developed a framework for evaluating a contractor's proposal against one possible area of selection criteria. Looking at the actual decision methodology, Pingel (29) proposed a "System for the Use of Evaluation Factors in the Source Selection of Service Contractors." Barclay and Nido (4) addressed the decision process by

> identifying a model of the source selection process, as used in Aeronautical Systems Division, Air Force Systems Command,...[to]... provide a basis for better understanding the quality of decision information provided by the process and form a framework for improving the source selection process.

In their report (4:11-16) they enumerated on other works in the decision area by Beard (7), Dawes (14), Dycus (16), Lee (24), Milligan (25), Peterson (28), Simon (35), Waid (47) and Williams (48).

However, a search of the literature has failed to surface any research specifically concerned with the selection of the most appropriate evaluation criteria for a particular procurement activity (apart from general guidance given in Department of Defense and service publications as discussed in Section II). Likewise, studies ignore how to best assist the project officer to expediently determine criteria and confidently assess their quality in his particular circumstances.

The Scope of the Research

This research effort will attempt to provide one answer to the question of how the project officer may be assisted in the selection of evaluation criteria by analysing historical data from completed source selections with the view to ascertaining the feasibility of creating an information system which will serve as a form of "corporate memory" for the program manager's task of creating the source selection evaluation criteria. The work will aim to determine whether a store of historical data can be compiled and processed to guide the inexperienced project officer on the track towards confident selection of sound evaluation factors, tailored to the peculiar circumstances of his project.

A point regarding the aim of this research should be made clear. The proposal is not to develop a system which will select evaluation criteria or in any way relieve the project officer of the responsibility of thoroughly investigating, analysing and understanding the characteristics of the system with which he is dealing and then determining which criteria are most appropriate to that system. Rather, the ultimate goal is to provide a tool for the project officer which will reduce the pain of the first flounderings in the search for the evaluation criteria and result in a more timely and better result. An operational database or software package will not be produced because,

as will be discussed in Section III, an operational package should be designed from the base up in conjunction with the several office automation systems that are currently under development. This research is seen more as an exploratory, feasibility study designed to establish a basis for the inclusion of source selection evaluation criteria in project office management information systems to ease the burden of work often placed on the inexperienced project officer because of the lack of good corporate memory in this area.

The data for the study will be taken from Source Selection Plans of source selections undertaken by ASD. While any conclusions drawn from examination of the data will thus only be strictly applicable to that scenario, the review of literature concerning the source selection process given in Section II will indicate that if a sufficiently general approach to the types of program and selection criteria is adopted, there is sufficient similarity in procedures Defense - wide for the principles to be valid for source selections conducted by most other defense agencies.

Summary and Preview

This section has briefly introduced the research setting, the nature of the problem, the question to be answered and the scope of the research. The following sections will explain in detail the entire research effort. Section II will present a review of the literature pertaining to the source selection process with emphasis on

the nature, need for, and importance of source selection evaluation criteria. Section III will treat the methodology used throughout the research by initially reviewing decision support systems in general, the decision process and support of that process, the nature of the decisions for source selection criteria determination and a suggested model of those processes. The same section will then describe the data used for the research, the data manipulation tools used and the development of a heuristic model for the support of criteria determination decisions. Section IV will present the findings derived from the processing and examination of the data to determine the feasibility of using the heuristic model as the core of a decision support system. Finally, Section V will summarize the research and draw conclusions, together with recommendations for further research in the field.

II. Literature Review

Introduction

This section will briefly describe the Source Selection Process, concentrating mainly on the source selection criteria. The official Defense publications which relate to Source Selection will be explored and those sections which give direction and guidance on the area of source selection evaluation criteria will be highlighted.

However, the review of this area of the literature will be confined to Department of Defense and United States Air Force publications. The justification for this approach is the statement contained in Department of Defense Instruction 5000.2, Major Systems Acquisitions (38), that "It is the policy of the Department of Defense to provide uniform procedures for the major systems acquisition process," coupled with the conclusion drawn by Turner (X1:34) that

> the Air Force tends to try to cover "all bases" with extreme levels of detail in its procedures while the Navy gives broad general guidance in most areas and leaves the buying organization to come up with their own procedures. The Army has mixtures of both with little guidance from Headquarters, DA, but greater detail from AMC.

Similarly, Babin (3:6) observed that "among the DOD components, the Department of the Air Force appears to have the greatest amount of regulatory material specifically devoted to the Source Selection Process."

Thus, a coverage of the information presented in that subset of the total Defense documentation should be sufficient to give an adequate survey of this area of the literature and yet conform to the time constraints of this study. For the reader who desires information on source selection related publications of the other Services Turner (36) gives a good, though dated, survey and Babin (3) adds a brief resume of civilian publications.

Regulatory Publications

The prime document covering U.S. Government procurement processes is Department of Defense Directive 5000.1, Major Systems Acquisitions (39) and the second priority document is Department of Defense Instruction 5000.2, Major Systems Acquisitions Procedures (38) each of which detail mandatory policy concerning the acquisition process for procurements designated as major systems.

The subsystem of the acquisition process which is termed Source Selection is governed by Department of Defense Directive 4105.62, Selection of Contractual Sources for Major Defense Systems (40). This publication gives more detailed policy and guidance on the source selection process for major Defense systems than does DODD 5000.1 or DODI 5000.2, but it is still at too high a level to be of significant practical assistance to the program manager.

The major USAF document is Air Force Regulation 70-15 (AFR 70-15), <u>Source Selection Policy and Procedures</u> (44), which

> . . . sets policy, assigns authority and responsibilities, and prescribes implementing procedures for soliciting and evaluating offerors' proposals. It also provides information for the selection of sources for development and production of major defense systems, subsystems, and components as well as other major programs or projects competitively procured by the Department of the Air Force [44:index page 1].

AFR 70-15, together with all other relevant defense regulations (27:4), implements the provisions of DODD 4105.62. Most other Air Force documents either amplify and clarify AFR 70-15 and DODD 4105.62 or delineate policy on situations not adequately covered by those regulations. For example, Headquarters Air Force Systems Command (HQAFSC) has produced AFSC supplement 1 to AFR 70-15 (45), and AFSC Regulation 80-15 (46). Further, AFSC Aeronautical Systems Division (ASD) produced ASD Pamphlet 800-7 <u>Source Selection Guide</u> (43) and a handbook <u>The Source Selection Process</u> (1).

The Source Selection Process

AFR 70-15 formally defines the source selection process as "The formalized process employed in competitive, negotiated procurements . . . designed to insure an impartial, equitable, and economic, evaluation, and comparative analysis of competing offerors' proposals and their capabilities [44:4]," and places dollar limits on

the major systems procurements with which it is concerned.

DODD 4105.62 (38:2) states the three primary objectives of the formal source selection process:

(a) select the source whose proposal has the highest degree of realism and credibility and whose performance is expected to best meet Government objectives at an affordable cost;

(b) assure impartial, equitable, and comprehensive evaluation of competitors' proposals and related capabilities; and

(c) maximize efficiency and minimize complexity of solicitation, evaluation and the selection decision.

AFR 70-15 (44:3) states as further objectives of the source selection process that:

> [The process] should be structured to properly balance technical, financial, and economic or business considerations consistent with the phase of the acquisition, program requirements, and business and legal constraints. It must be sufficiently flexible to accommodate the objectives of the acquisition and a decision must be compatible with program requirements, risks, and conditions.

Within the USAF system there are three formal, but distinctive, methodological approaches: the "Formal" (three-step) source selection organization; a "Streamlined" (two-step) organization; and the "Four-Step" organization. The latter was instituted into the Defense Acquisition Regulations with the issuance of the September 1978 Defense Acquisition Circular (DAC-76-17) (1:7-11).

The Formal Source Selection Organization as prescribed by AFR 70-15 is a three tiered, pyramidal structure with, at the apex, the Source Selection Authority

(SSA), an "official designated to direct the source selection process, approve the selection plan, select the source(s) and announce the contract award [44:4]." He is served by a Source Selection Advisory Council (SSAC) which acts as his staff and advises him on the findings of the Source Selection Evaluation Board (SSEB). The SSEB, at the base of the pyramid, is a group of functional and technical experts who "direct, control and conduct the evaluation of the proposals and develop summary facts and findings [43:6]."

The organization for most source selections follows the same basic outline; however, there is sufficient flexibility in the regulations to permit adjustment of the organization to suit the circumstances. For example, where previous experience has shown that the SSAC review level is not necessary, the SSAC and SSEB functions can be combined into a single Source Selection Evaluation Committee (SSEC) (the Streamlined Source Selection Organization) (1:9; 44:4; 43:7-9).

Babin (3:2,3) concisely describes the major events in the source selection process as:

(a) Identification of a need and creation of a plan to satisfy that need.

(b) Communication of the need to industry, via solicitation. This is usually done by issuing a Request for Quotations (RFQ), or . . . a Request for Proposals (RFP).

(c) Evaluation of proposals and the establishment of a competitive range. Those proposals found to fall

outside the competitive range are eliminated from competition.

(d) The conduct of written and/or oral discussions with those offerors within the competitive range.

(e) The evaluation of best and final offers following discussions.

(f) Selection of the offer most advantageous to the Government.

(g) Award of the contract.

The "Four-Step" procedure, which is applicable to all competitively negotiated research and development acquisitions, differs significantly from the conventional method described previously in three main aspects:

> the offeror's technical and cost proposals are not submitted and evaluated simultaneously, definitive contracts are not negotiated with all offerers in the competitive range, and the apparent contractor is selected and announced prior to negotiation of a definitive contract [1:11].

In particular, the offerors do not learn of their proposal's deficiencies until during Step Four when they are disclosed and resolved as part of the negotiation of a definitive contract.

The need to activate the source selection process is triggered by submission of a Justification for Major System New Start in response to the submission of a Required Operational Capability (ROC) by a user command. Those activities result in the issuance of one or more Program Management Directives (PMD) (44:7). The PMD guidance directs the Program Office in its preparation of the Source Selection Plan (SSP), the key planning document which

defines the organizational approach to the source selection process (43:3).

The Source Selection Plan (SSP) gives the source selection process unity and purpose of direction. It lays out the ground rules and, in particular, defines the criteria on which the proposals will be evaluated and the method of evaluation. These source selection evaluation criteria are the heart of this research.

Source Selection Evaluation Criteria

The SSP and its evaluation criteria will, or ideally should, be specifically tailored for each individual procurement situation. The February 1984 issue of AFR 70-15 (44:8) explains that:

> Award will be based on an integrated assessment of each offerors' ability to satisfy the requirements of the solicitation. The integrated assessment will include evaluation of general considerations as well as the results of the evaluation of the proposals against specific criteria.

As examples of the general considerations it includes past performance, proposed contractual terms and conditions, and the results of preaward surveys. It further elaborates on evaluation criteria by differentiating between specific and assessment criteria.

> The assessment criteria relates to the offeror's proposal and abilities. They typically include but are not limited to such aspects as soundness of technical approach, understanding of the requirement, compliance with the requirement, past performance and the impact on the schedule.

Specific criteria, on the other hand, relate to the program characteristics. Typically they fall into five broad areas:(44:9)

a. technical,

b. operational utility,

c. logistics,

d. management,

e. manufacturing, and

f. test.

The specific and assessment criteria "provide a matrix that identifies and interrelates what is to be evaluated [44:8]." The assessment criteria are thus a means of measurement within each of the specific criteria areas, items, and factors. An example of the prescribed general format for the matrix of the evaluation criteria is given as Figure 1. This research is primarily concerned with the specific criteria and for the remainder of the paper "criteria" should be read to mean "specific criteria" unless otherwise qualified.

The specific criteria are usually broken down into "Areas," "Items," and "Factors." Areas are the basic functional disciplines listed above which will impact on the success of the program and the ultimately procured system. Items are a more specific breakdown of the areas to permit proper analysis and evaluation. Further breakdown reveals Factors, or even Sub-factors if appropriate, which are the

GENERAL FORMAT FOR MATRIX OF EVALUATION CRITERIA
AREA
(Technical, Logistics, Test, Management, etc.)

Specific Criteria / Assessment Criteria	Item 1 Description		Item 2 Description		Item 3 Description	Item 4 Description
	Factor 1	Factor 2	Factor 1	Factor 2		
Soundness of Approach	COLOR	COLOR	COLOR	COLOR		
Understanding of Requirement						
Past Performance						
Compliance with Requirement						
Other Assessment Criteria						

NOTES:
1. If a factor is displayed graphically it must be color coded.
2. If one factor for an item is displayed, all factors for all items within the area must be displayed.

Figure 1. Evaluation Criteria Matrix Format [44:19]

criteria or standards against which the SSEB makes its evaluations. An example of the breakdown of areas into their sub-parts is (taken from the previous issue of AFR 70-15 dated 16 April 1976):

```
Area-Operations(identified by the SSAC)
 Item-Maneuverability  (identified by the SSAC)
   Factor-Turn Radius(identified by the SSEB)
   Factor-Excess Power (identified by the SSEB)
 Item-Survivability
   Factor-Subsystem redundancy
   Factor-IR reduction
   Factor-Radar cross section
     Subfactor-Front quarter
     Subfactor-Side view
```

Proposals are evaluated or scored by a variety of methods, and considerable latitude is given as to which method is employed in any given instant. The two extremes of subjective and objective evaluation methods are narrative assessments and numerical scoring respectively. A compromise system seeking to retain some of the advantages of both systems is a color code assessment system. Whichever method of scoring is used however, the proposals are rated by comparison against standards, not by comparison against each other(44:9; 1:60; 46:2-1).

The proposals are evaluated against the predetermined standards by evaluators on the SSEB and the results are submitted as a SSEB Evaluation Report to the SSAC. The SSAC analyses the SSEB report, considers the relative strengths, weaknesses, and risks and presents the final SSAC Analysis Report to the SSA. The SSA is the authority which makes the ultimate source selection and announces the contract award. (44:4)

Synopsis

The current USAF source selection processes have been examined, but to fully understand them requires a background history to gain an appreciation of how and why the present system developed. Turner (36:5-20) provides a very concise but comprehensive description of Defense policy, regulations and guidance current at 1975. Comparison of previous regulations since 1960 with current

regulations indicates that the source selection process is probably far from maturity. The rate of change of regulations which has been maintained until the present with no apparent levelling out suggests that there may still be improvements to be made in the procurement system.

Further evidence of the continuing evolution of the source selection process was furnished by an initial search through decisions and unpublished decisions of the Comptroller General of the U.S., from 1960 through to April 1983, by FLITE (Federal Legal Information Through Electronics, Denver, Colorado), which revealed seventy-one protests directly related to the source selection process. A majority of the actions occurred in recent years which may suggest the source selection arena is becoming more turbulent rather than maturing into a well tried and stable system. There are indications that the problems are well recognized (43:11), but the field is ripe for further research in the pursuit of a better process.

Conclusion

The USAF Source Selection Procedures have evolved over many years and with the experience of many practical applications. The procedures are well documented in numerous Department of Defense and Department of the Air

Force publications. Additionally, many of the user organizations have added their own manuals to the wealth of regulatory and guidance materials.

The field has been well researched and will most likely continue to be so because of indications that the source selection procedures, although well tried, are far from perfect. An area which is ripe for research, and toward which this thesis effort will be directed, is the determination of the Source Selection Criteria.

III. Research Methodology

Introduction

The goal of the research methodology is to devise a way to examine and process the source selection evaluation criteria actually used in past Source Selections, in order to provide an inexperienced Program Manager with an aid for determining source selection evaluation criteria.

The process of determining the evaluation criteria for the selection of a source during new systems acquisition is a complex decision process. In very simple terms, the program manager must research the system undergoing acquisition, determine with the help of expert advice the key variables upon which the selection of the optimal source depends, and then operationally define and weight the significant variables which become the evaluation criteria.

The fact that this is a complex decision process leads one to consider the prospect that a decision support system (DSS) may be useful to the program manager. A further factor common in source selections is that the responsible program manager often does not have much, if any, experience in this area of endeavor prior to assignment to a program office. A DSS may thus be useful not only to support the decision, but, through intelligent and practical design it may be developed as a tool to lead the inexperienced program manager through the investigative

procedures necessary to arrive at a position from which sound decisions are possible. This, of course, assumes that the whole process can be modelled in a structured or semi-structured form.

Two areas of required initial research are thus evident. The first requirement is to examine the theory and science of decision support systems, their design, evaluation, and justification. The second is to analyze the source selection evaluation criteria determination process and model it in a form supportive of the design and implementation of a DSS. The success of the venture will be dependent on the satisfactory modelling of the system and the availability of DSS technology adequate to the task of constructing a useful tool.

Decision Support Systems Overview

The U.S. Army Research Institute for the Behavioral and Social Sciences has developed a Decision Support Framework for Decision Aid Designers (20). Their framework lists the steps a decision aid designer should ideally complete in the full development and implementation of the aid or aiding system, and distinguishes two categories of aids, those that provide information, and those that provide support for logically and rationally evaluating and integrating information in making a decision. The first category of aids is termed Information Aids and the second

category Integration Aids. A schematic of the framework is given as Figure 2.

The aim of a decision support structure such as just described is to increase the range of a decisionmaker's capabilities to make a rational decision. This aim implies the acceptance of the principles that decision support is used when human judgment is a critical element of the decision process, and decision support in no way replaces the decisionmaker as the problem solver. Consequently the aid to be developed here will be a tool to support the human judgment and decision-making process.

The pivotal point of the framework is the actual <u>decision</u> to be made. An analysis of that decision provides the basis for definition of the information and tools needed to make the decision. These determinations make up the Decision Requirements. The quality of the analysis which results in the formulation of the decision requirements will determine the appropriatness, quality and comprehensiveness of the final decision support system design.

From the decision requirements will emerge the basic form of the system. For convenience it may be developed in two stages, Information Aids and Integration Aids. The Information Aids may be further subdivided into two categories, Data Based Aids and Calculation Aids. Data Based Aids make available to the decisionmaker the data on which the decision is based; automated data banks providing

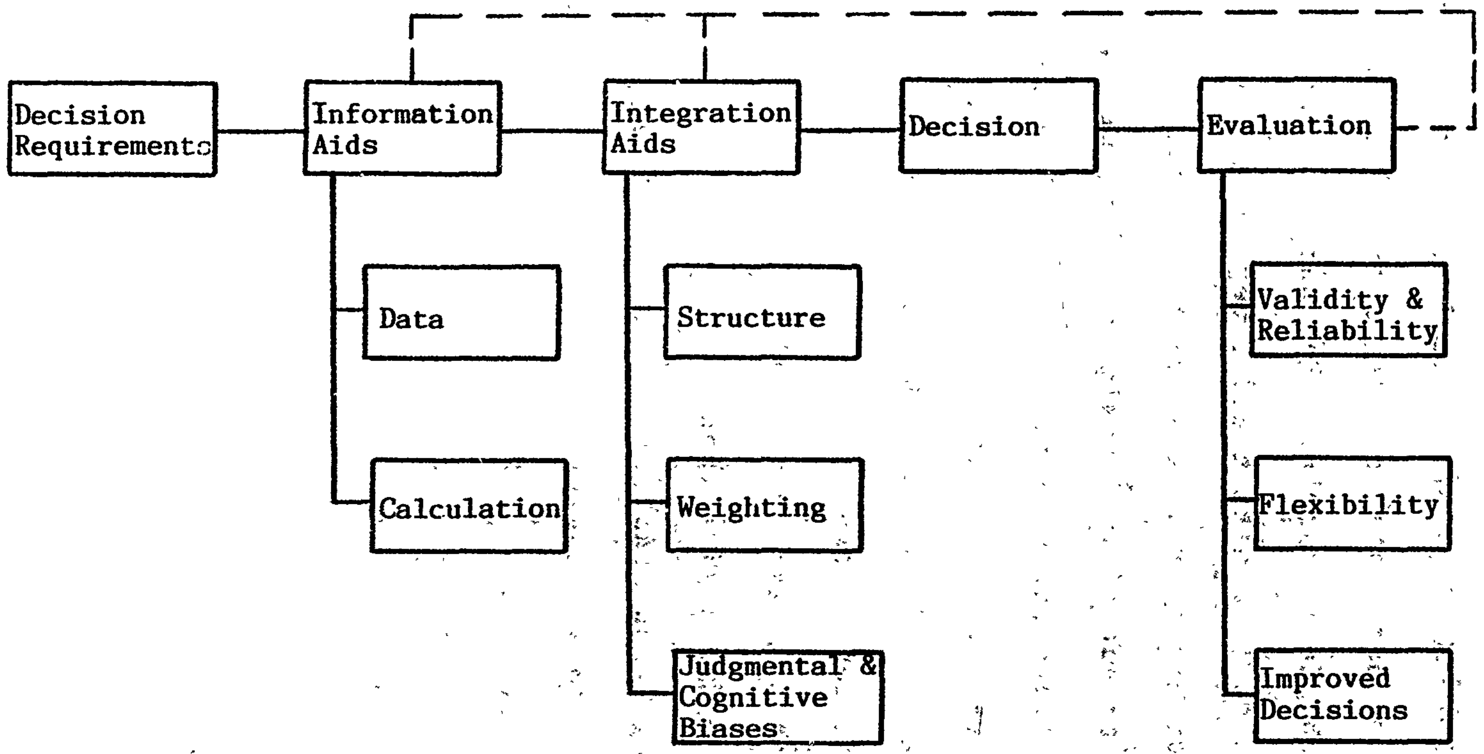

Figure 2. The Decision Support Framework (20:3)

raw or summarized data, on call, in accordance with either pre-determined or user-specified criteria. Calculation Aids perform mathematical or statistical computations on data drawn from the data base or other sources, and present the results to the decisionmaker. The output of both subdivisions of Information Aids, regardless of its form, is at best information or at the least raw data.

The output of well designed Information Aids is often appropriate and sufficient for the decisionmaker to arrive at a satisfactory decision. But just as often the sheer volume of information made possible by, and available from, the aid can overwhelm the decisionmaker's cognitive abilities and make filtration and logical evaluation of the information a formidable task.

Integration Aids are sets of procedures designed to help a decisionmaker logically evaluate and integrate the information provided by information aids. Their composition and organization depends on the characteristics of the decision problem which hopefully have been recognized in the Decision Requirements analysis. They may serve to organize and structure information, simplify the evaluation and weighting of information, help overcome judgmental and cognitive limitations and biases, and reduce any other psychological difficulties known to influence the class of

decisions with which they are concerned. Ultimately the goal of every Integration Aid is to help the decisionmaker arrive at a logical, rational decision.

Having observed a decisionmaker arrive at a decision, the DSS designer should evaluate the support given to the decisionmaker at least in terms of the validity and reliability of the aid, its flexibility, and the degree to which it led to an improved decision. Such evaluation capacity should also, to some extent, be built into the support system in order to maintain it as an aid of the highest calibre and ensure its continued validity, reliability, and flexibility.

Decision Concepts

The analysis of the decision process and the resultant definition of the Decision Requirements is thus the focus which gives the DSS design direction and is fundamental to the success of the support system. Keen and Morton's Decision Support Systems: An Organizational Perspective (23) is recommended as an excellent text on which to base such an analysis.

Keen and Morton identify five main schools of thought on conceptions of decisionmaking:

a. Rational Man. The classical conception of decisionmaking assumes a rational, completely informed, single decisionmaker using a normative decision methodology and able to evaluate all alternatives.

b. <u>Satisficing Man</u>. H.A. Simons (23:62) satisficing decisionmaker is practically constrained by "bounded rationality," and so arrives at a "good enough" solution by using heuristics.

c. <u>Organizational Procedure</u>. Cyert and March's (23:63) organizational process view sees the decision as a function of the interrelationships among components of an organization, highlighting a simplified and systematic procedure with organizational structure, mechanisms for communication and coordination, and standard operating procedures.

d. <u>Political View</u>. The political view represents the decision as the product of a bargaining/-conflict process between organizational subunits; coalitions of individuals with vested interests, where power and influence determine the outcome of any given decision.

e. <u>Individual Differences</u>. The individual decisionmaker has personality and style which determines his approach to a decision problem, his cognitive ability, and the degree of subjectivity of his personal rationality.

These five conceptions of the decision process range from entirely normative to entirely descriptive, but everyday experience of decisionmaking would suggest that most decisions in reality contain elements of more than one of the given models. Thus the analysis of the decision situation selected for support, and the subsequent model building process, should adopt an eclectic posture and avoid the unwarranted ommission of any viewpoint from due consideration.

Decision Supportability

This leads one to consider the question of which categories of decisions are computer supportable. Simon introduced two general categories of decisions relevant to this problem, programmed and nonprogrammed decisions. He explained (34:5-6):

> Decisions are programmed to the extent that they are repetitive and routine , to the extent that a definite procedure has been worked out for handling them so that they don't have to be treated de novo each time they occur. Decisions are nonprogrammed to the extent that they are novel, unstructured, and consequential. There is no cut-end-dried method of handling the problem because it hasn't arisen before, or because its precise nature and structure are elusive or complex, or because it is so important that it deserves a custom tailored treatment. . . . By nonprogrammed I mean a response where the system has no specific procedure to deal with situations like the one at hand, but must fall back on whatever general capacity it has for intelligent, adaptive, problem-oriented action.

Keen and Morton substituted the names structured and unstructured for programmed and nonprogrammed respectively,

and introduced a third category; semistructured. They considered that in the context of computerized decision support, the structured decision would be well enough understood to be given in its entirety to clerks and automated through the computer, thus not involving a manager at all. An unstructured decision, on the other hand, is not capable of being programmed or appears to be so because it has not yet been examined in sufficient depth. In either case the decision is made by the manager and decision support is not yet possible. The category of semistructured decisions covers that very broad area between the two extremities of structured and unstructured decisions, where a DSS can be most effective. It is here that neither managerial judgment nor a computational system alone is sufficient to provide a solution because the first cannot cope, perhaps, with the size or complexity of the problem, and the other cannot provide a necessary subjective analysis.

A final word is appropriate on the design model and the system process. Decision support models applicable to the semistructured decision category must differ substantially from the optimization algorithms used in the structured area. The best models will probably be simple, small and informal, eliciting better answers than currently achievable rather than dangerously non-subjective optimum solutions, and which represent a manager's concept of the

key interactions of environmental variables. Along the same lines, the users should ideally be involved in the development of a DSS in order to create a tool which will most useful in practice, and will grow according to a user driven evolutionary process throughout its useful life. This is the concept of bottom-up development.

Tackling the determination of the Decision Requirements, one must make an intuitive assessment of the style of DSS which will be most suited to the decision situation and proceed with the decision analysis on that basis. Again, user input to DSS pre-design at this point is highly desirable. The question of the DSS style relates to the desirability of designing a DSS based on a normative model, which achieves the objectives of the decision process but may be radically different from the present decision process, or whether a model based on descriptive analysis of the present process is preferable. The potential payoff of the former style of DSS, if such a model is possible, may be huge, but design, development, and implementation is likely to be long, expensive, and risky. The latter type of DSS, which is very little distant from the descriptive system, represents a reinforcement of current practices with probably a relatively low payoff. However, implementation should be easy and, if well designed, should encourage the evolutionary growth previously discussed. The potential payoff in the long term may thus be high and the likelihood

of success is very much greater. The decision support design objective selected for this project will therefore be to create a tool to enhance performance largely within existing procedures, and the decision model will be descriptive of the current processes.

<u>The Evaluation Criteria Determination Process</u>

The procedure followed by a program manager to determine the source selection evaluation criteria will vary with individual preferences from manager to manager and also from project to project as experience with source selections for similar systems varies. The approach adopted here to cater for these individualities will be to build a descriptive model, based on discussions with practising professionals in the field, of a typical but contrived procedure which is considered representative of actual practice. The limitations of this approach are recognized, but in the interests of convenience and hence practicality, it will serve to establish the validity of the concept of the DSS, which is the prime objective of this effort. A practical DSS destined for a specific installation must, of course, be designed with the peculiar requirements of that particular installation always in view. A diagrammatic overview of the contrived procedure is given in Figure 3, and the first level of analytical detail in Figure 4.

The Program Manager's search for the evaluation criteria to be used in a given source selection is

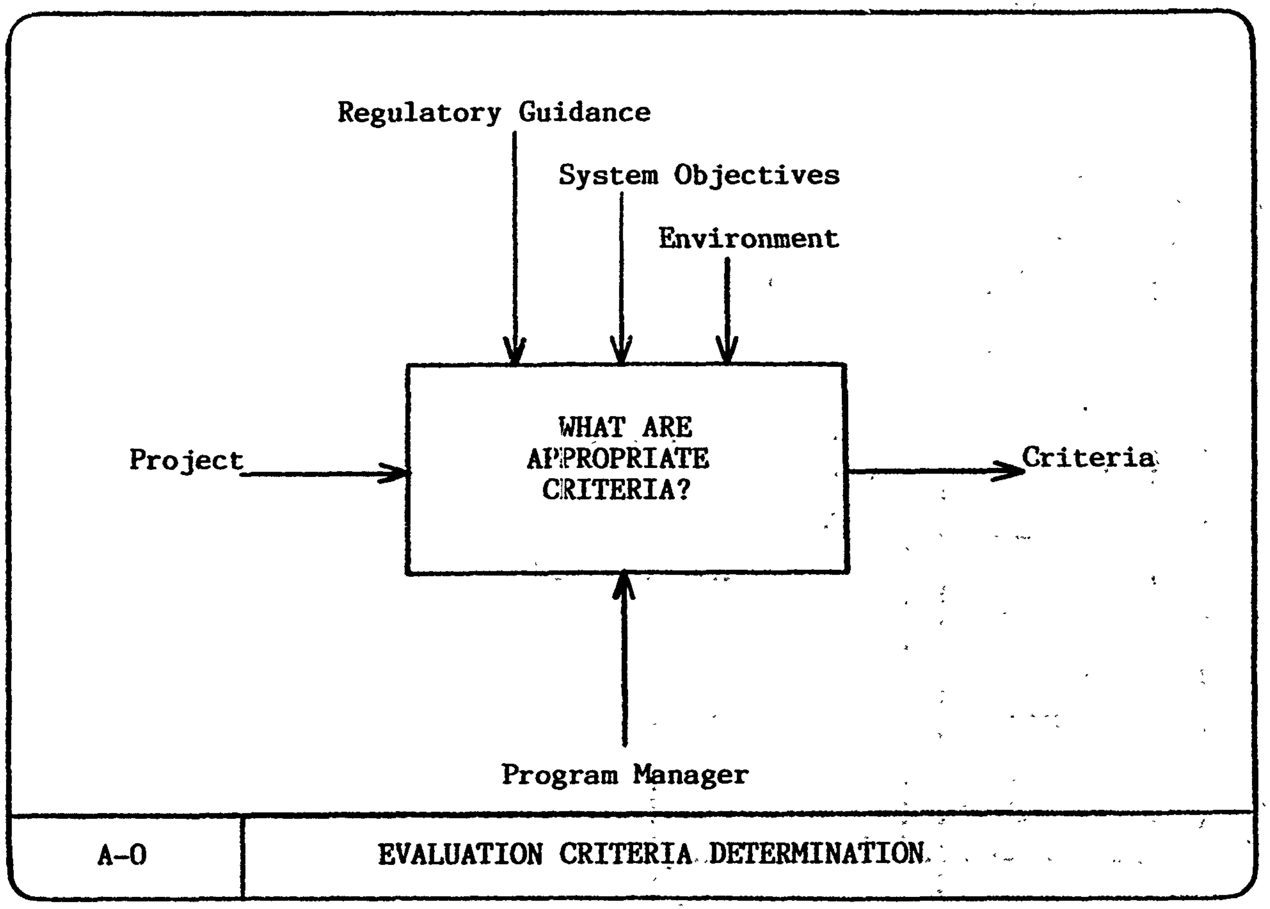

Figure 3. Evaluation Criteria Determination Process Overview

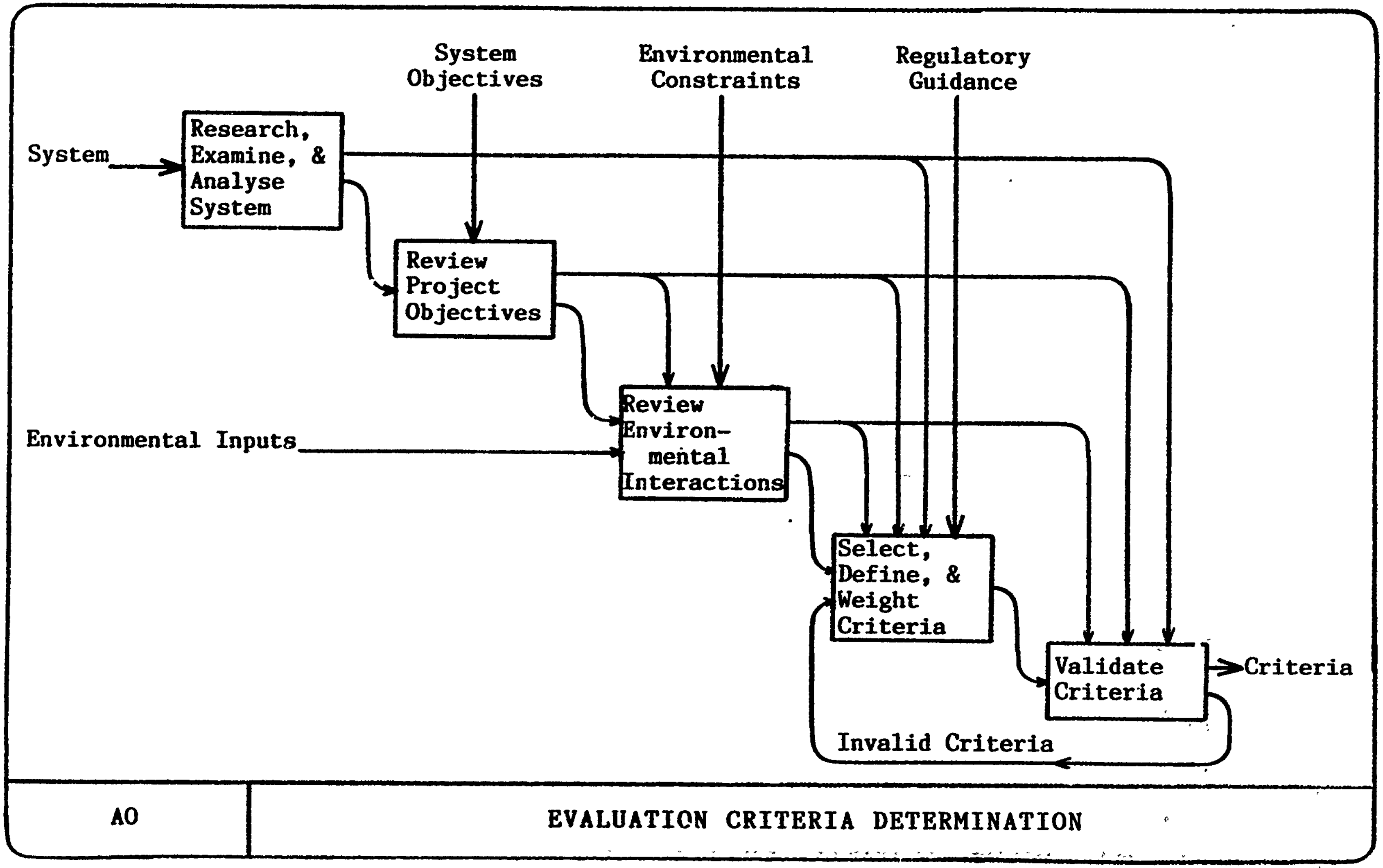

Figure 4. Evaluation Criteria Determination Process Detail

undoubtedly a decision process. At the highest level of abstraction the entire process is directed by a question: "What are the appropriate source selection evaluation criteria for this acquisition?"

The first and most basic requirement for the PM is to research, examine, and analyse his system. This is fundamental to the PM's raison d'être and to the success of the source selection. In the context of the procurement of a sophisticated and complex major system, the PM would not of course be expected to be fully intimate with every detail of the system. In these cases (the majority of cases) one should read PM to mean "a team of experts drawn from a balanced selection of appropriate fields." Similarly fundamental, the PM will need to be fully conversant and comfortable with the objectives of the project and the environmental inputs which may impact on the choice and performance of a contractor.

The environment may be so complex and dynamic, particularly in the case of a high dollar value project with strong political overtones, that the PM may need a formal environmental scanner, or in other cases, perhaps the experience, intuition, and judgment of the PM may be a sufficient environmental compensator/reactor.

The PM must then select, define, and weight the criteria. The recognition of the influences and relative importance of the inputs discussed to this point provide a

basis for differentiation among criteria, but the immediate problem now is where to find an initial criteria set to catalyse the process. A brief look at some categories of evaluation criteria may be helpful at this stage.

The evaluation criteria typically used in source selection may be categorized into three hierarchical levels:

a. Compulsory Criteria. Certain evaluation criteria are prescribed by regulation and must be included in either all source selections or specifically designated source selections. For the selection of these criteria, the decision is out of the hands of the Program Manager (PM) or the Source Selection Authority (SSA).

b Recommended Criteria. Certain other evaluation criteria are strongly recommended by Regulations or official handbooks. Here there is some measure of discretion available to the PM and the SSA.

c System Related Criteria. The remaining criteria are those which are selected solely on the basis of their relevance and importance to the unique system being procured.

The criteria may then be further broken down into Areas, Items and Factors in the manner described in Section II and AFR 70-15 (44:9,19).

While the Compulsory and Recommended Criteria as described above should present no insurmountable problems for the PM in their inclusion in his set of criteria, their origin and authority can often be obscure and they may escape the attention of an inexperienced PM. Further, they may still need to be divided into Items or Factors and require some analysis for their precise definition in a given procurement situation.

System Related Criteria can give the PM considerable trouble, first in identification as significant factors in the contracting process or system life-cycle, and secondly in the determination of their validity and relative importance. That assertion is widely supported. Carnes (8:20), for example, concluded during a Source Selection case study that "the most difficult task in preparing the Source Selection Plan . . . was the development of the source selection criteria."

There appears to be two ways to attack the problem. One is to try to arrive at the criteria by intuition, extensive research, survey of expert opinion, trial and error, and so on, but this method usually takes considerable time, is risky, and is inefficient unless the PM has a good deal of experience in similar projects or acquisition from which to draw. The alternative, and also the most commonly used approach, is for the PM to search back through the files of previous Source Selections until he finds a project

with similar characteristics to those of his own project and then uses the evaluation criteria recorded therein as his starting point. Unless abused by an overly ready acceptance of the previous criteria as they stand and without due regard to the peculiar requirements of the current situation, then this procedure is relatively fast and useful.

Having determined a starting set of criteria, they can then be compared to the various requirements of the system, the objectives of the project and the environmental inputs. The criteria can be modified and honed by an iterative process until a satisfactory set is arrived at. They must then be operationally defined since they provide the standards against which competing proposals will ultimately be measured. Further, since not all criteria will be of equal importance they must be ranked and weighted. This is typically done by expert opinion, regulation, and the use of a suitable technique such as value analysis, value building, or multi-attribute utility techniques.

The criteria must then be validated. Validation may be simply some sort of review and approval process as would be provided by a Source Selection Authority, or it may also include a more rigorous examination using sensitivity analysis or simulation. Finally the evaluation criteria is written into the Source Selection Plan and the decision process is complete.

The Decision Model

The specific portion of the model thus far described which is attractive for the incorporation of decision support because of its large number of inputs and constraints is the section in which the evaluation criteria are selected, defined and weighted. This area will be examined in more detail.

If the assumption is made that the PM will review the historical records in search of the latest similar source selection as a starting point in the determination of criteria, then Figures 5 and 6 show a typical procedure.

The figures contains only the search of historical records and the decision process for use or rejection of the historical data. If modular, bottom-up evolutionary development is accepted as a valid practical approach to DSS construction then this small section of the model appears to be a good place to start.

The PM searches backward through the files of previous source selection activities until he finds a system which is comparable with his own project. He then extracts the evaluation criteria that were used in the past source selection and divides them into the subsets of Compulsory, Recommended, and System Specific Criteria as described previously. The Compulsory criteria may be recorded immediately for use in his own source selection.

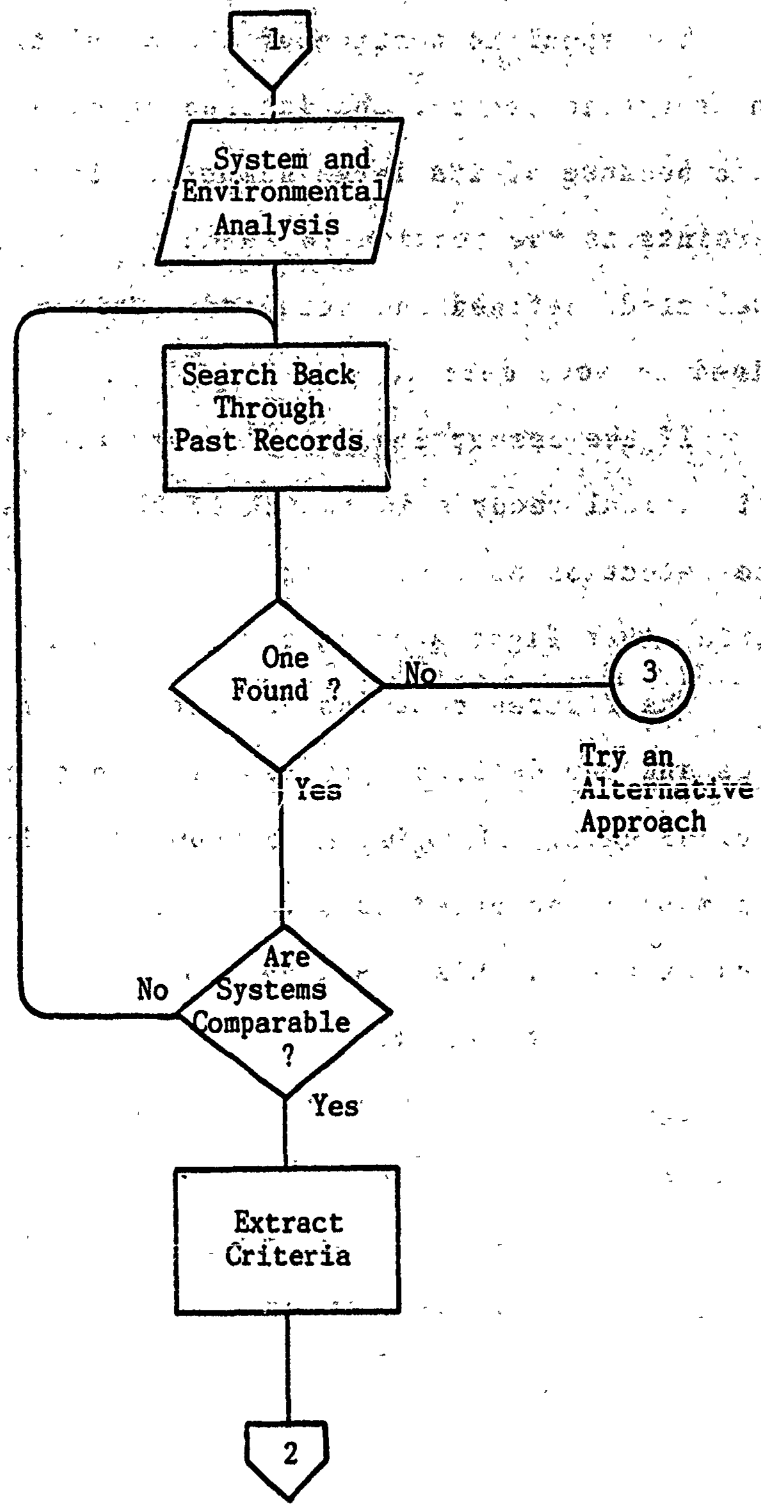

Figure 5. Criteria Determination Procedural Flow

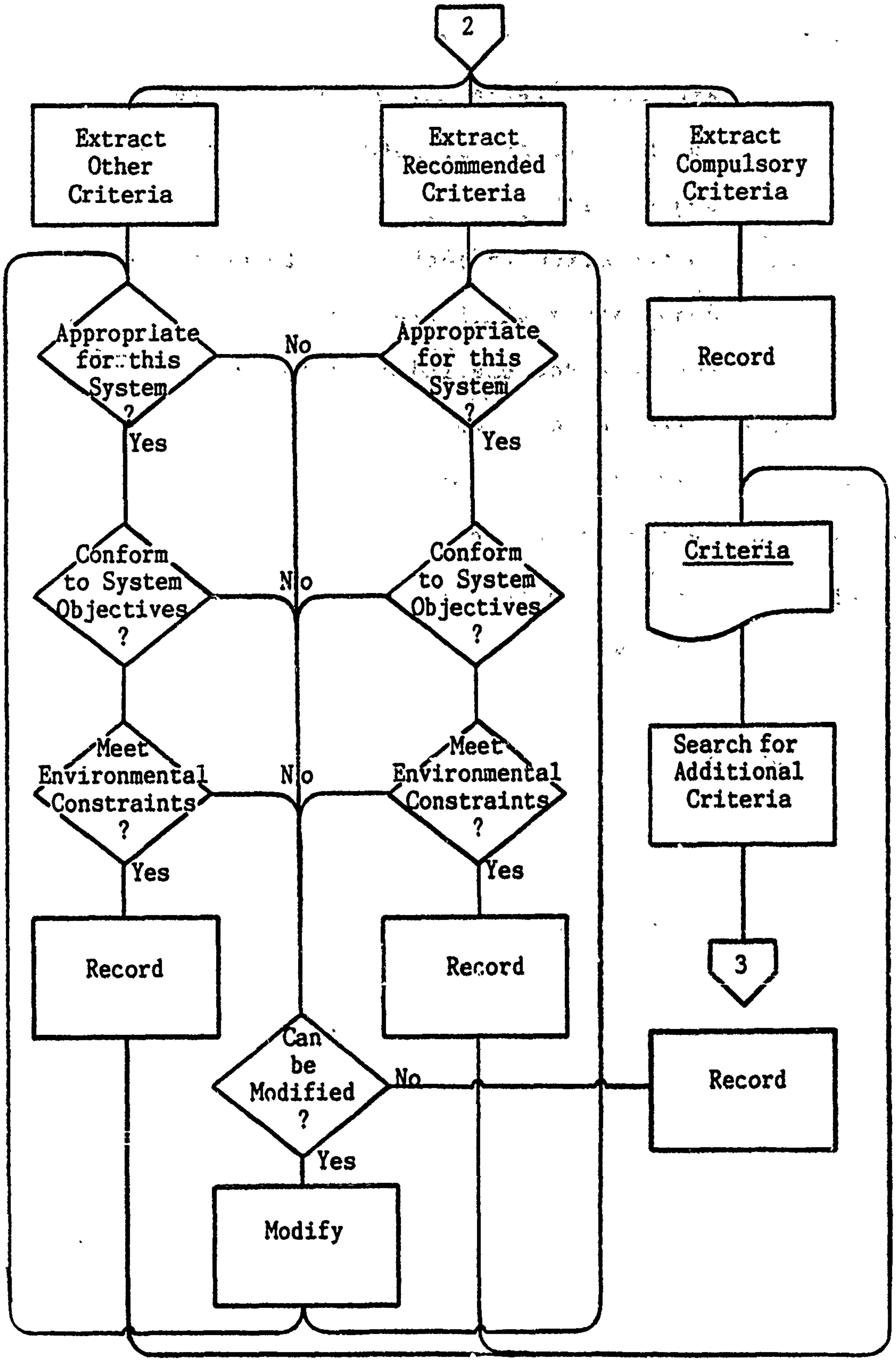

Figure 6. Criteria Determination Procedural Flow (continued)

The other two subsets must be examined in the light of the following considerations:

a. Are the criteria appropriate for this system?

b. Do the criteria conform to the system objectives?

c. Do the criteria conflict with environmental constraints which are present at this time or forecast for the relevant future?

If a criterion does not pass all these tests then it may be considered for its potential for acceptance if it is modified to counter its deficiencies. It will either undergo modification and retest or be discarded. Successful criteria will then be recorded as the compulsory criteria were.

The testing process for the non-compulsory subsets is divided into two separate channels because the slightly different nature and emphasis of the two categories would normally require different comparative processes and environmental impact considerations. A more efficient decision process will often be achieved by considering them as (subtly) different processes.

A starting list of appropriate criteria now exists to which should be added further criteria which are either compulsory or recommended criteria and which the PM observes as having been omitted from the historical data or system

specific criteria which the PM develops from scratch. This is a reversion to the first method described earlier and could take considerable additional time. The final list of criteria thus obtained would then be subject to further scrutiny, sensitivity analysis, etc to ensure that only important, relevant and non trivial factors were included in the final set.

The Support Structure

The fact that there have been a multitude of programs and therefore Source Selections in the past, suggests that the store of historical data available is very large. This would be true except for two constraints. Firstly, because of the sensitive nature of source selection records and the requirement to safeguard that information, there will only be a limited quantity retained in the source selection offices and thus readily accessible by the PM. Secondly, the constraints of time imposed on the PM means that he would normally not be motivated to search further than the first, or maybe second, file containing suitable data.

On the other hand, if the total experience obtained on all previous source selections could be aggregated and data that could serve to assist the PM on his particular project be presented to him in a useful form, then the beneficial input from all comparable past source selections could be focussed into the current project. Here then is

the first part of a DSS module; the data base, an Information Aid.

However, to rest with just the data base and a retrieval structure would be premature. With the outputs gained from the earlier stages of the evaluation criteria determination process and the output of the information aid, the incorporation of a good Integration Aid would produce a very effective decision support module.

The benefits would be the assimilation of far greater volume of historical data, the ability to incorporate a greater number of environmental inputs, probable reduction of human biases during criteria testing, shorter search, processing and selection time and less likelihood of not considering or overlooking an important criteria. Indeed, the effect of the vastly increased base of historical data may reduce the need to search extensively for further criteria to virtually zero so long as the new system is not so unique as to be revolutionary.

The Database

The database to be used for the research is drawn from Source Selection Plans for previous source selections dating from 1971 and held on file at Aeronautical Systems Division (ASD), Air Force Systems Command, Wright-Patterson AFB. The database thus obtained consists of 81

sets of evaluation criteria from acquisitions covering a broad range of systems for which ASD was the program agency.

Limitations of the data sample arise primarily from convenience, expense, and data sensitivity. Conveniently, the data was drawn only from the files of ASD even though there are numerous other agencies which conduct source selections. Such a restricted division of the total population means that the types of weapons systems included in the sample will not be representative of all systems procured by DOD or even the USAF. However, the range of systems included in the data set will be adequate to establish the feasibility of the methodology and thus will satisfy the objectives of the research as detailed in Section I. Consequently, the additional time and expense involved in acquiring a broader database was not considered to be warranted.

The nature of the Source Selection Process makes any information drawn from the files of previous proceedings sensitive to some degree. Thus the information used for the database was confined to that information which was made public by virtue of its use in Requests for Proposals (RFPs) during the acquisition process. Extension of the research to include, for example, weightings applied to evaluation criteria would have required the research to be classified and access to the data may have presented problems. Those studies may be undertaken profitably by researchers

operating in a more appropriately controlled environment.

Database Management System

Manipulation of the data set required the selection of a database management system capable of recording, sorting, searching, and reporting data in an appropriate and convenient manner. Several options were available.

Broadly speaking the alternatives were to create a new database management system from scratch using a high level programming language such as Fortran, Pascall, Basic, or Simscript, or to use a proprietary database management system. Since the objective of this effort is to address the concept and feasibility of a decision support framework, the latter/option of a commercially available software package was selected for its convenience and simplicity. For follow-on work in more specific design situations the selection would demand a reassessment for its continued suitability. The number and variety of available database management systems is large and growing rapidly. They range from large and versatile packages requiring mainframe computer facilities to extremely simple electronic filing systems designed for use on the smallest personal microcomputers. In order to make a reasonable choice from among the myriad of alternatives the author developed the following selection criteria

a. Adequacy of database capacity.

b. Ease of use.

c. Time to learn (since the author did not have operator familiarity with any suitable package).

d. Data manipulation capability.

e. Report presentation capability.

f. Availability.

g. Convenience.

The system which best satisfied the aggregate of these criteria and which was therefore selected as the management tool was an assembly-language relational database management system, produced by Ashton-Tate, Culver City, CA, called dBASE II.

The principal advantages of dBASE II were its availability (it is a very popular and commonly used software package for microcomputers), convenience (it could be run on the author's personal Apple II+ microcomputer), ease of learning, and its ability to output reports in suitable format for use with Wordstar, the word processor being used to produce this thesis. Furthermore, dBASE II is already in use in the contracting and acquisition arena (6; 17), in program offices and in some source selection facilities (5). Thus there appeared to be some benefit in remaining with a cheap, commonly used, and familiar system which may encourage users to attempt the development of decision support aids even in times of stringent budgetry constraint. But the selection criteria used are appropriate

only for the instance of this research and may not be appropriate in other circumstances, particularly if trying to design an actual decision support system for use in a source selection activity. dBASE II has major limitations which would indicate its unsuitability for many operational applications. For example, the limitations on record size (ie. the number of characters per record is 1,000 maximum, fields per record 32 maximum, and characters per field 254 maximum), the slow speed of sorting oprations, and its limited search capabilities would probably severely restrict its use in a DSS. Indeed, the restriction of a maximum of 32 fields per record slightly degraded its effectiveness in this application and will lead to a recommendation in Section V that future researchers should move to a system with greater capacity.

Data Processing

The data was entered into the dBASE II database as closely as possible to verbatim from the set of Source Selection Plans. In most plans the source selection criteria areas and items were given as paragraph headings and direct transcription was possible. A few plans however included the description of the criteria within prose and the author's best interpretation of the criteria was recorded. Wherever possible key words were transcribed from within descriptive paragraphs.

Each record within the database then consisted of 32 fields containing the following information:

1. Name of project
2. Phase of the Acquisition cycle
3. General description
4. General description
5. General description
6. Contract type
7. Approximate date of the Source Selection
8. Area
9. Item
10. Item
11. Item
12. Item
13. Area
14. Item
15. Item
16. Item
17. Item
18. Area
19. Item
20. Item
21. Item
22. Item
23. Area
24. Item
25. Item
26. Item
27. Item
28. Area
29. Item
30. Item
31. Item
32. Item

The name of the project was included for each source selection plan to facilitate reference to the original data by the author for data entry confirmation and review, but due to the sensitive nature of source selection information and the undertaking given by the author to the data source at Aeronautical Systems Division, the project names will not be included in any output published in this document.

The following five data fields provide a keyword description of the weapon system being procured including, in the first field, the phase of the acquisition cycle during which this source selection was initiated, and in the last field the type of contract to be awarded, if known. These data fields should, collectively, and in broad terms describe the type of system and the type of procurement activity as it may have relevance to the determination of the source selection criteria.

The date field was included only to facilitate sorting the data into rough chronological order and, for the reasons of source selection information sensitivity cited previously, will not be output in any reports. The desireability of having the data arranged in rough chronological order lies in the assumption that if program managers do indeed refer to recent previous source selections for guidance in the determination of source selection criteria, patterns of similarity between criteria sets may be more easily recognised during a scan of the data if the plans are grouped according to temporal criteria.

Data fields were then reserved for entry of evaluation criteria including up to five areas with up to four items per area. This was the most significant limitation imposed on the research by the selection of dBASE II as the manipulation tool. Only a total of 25 data fields were available for entry of the evaluation criteria areas

and items. While the five area fields were adequate for all the Source Selection Plans in the data set, several plans contained more than four items in one or more areas and very few plans contained a large number of items in one or two areas. However, in these cases the items were very system specific, were not matched by any other plan in the data evaluation criteria for a very closely related system. Thus their necessary ommission from the database was not considered a significant cost in this effort when related to the other benefits of using the dBASE II program. In other situations this may not be the case and the use of an alternative database management system may be desirable.

The database was sorted on the date field into ascending order and all fields except the project name and date were printed out.

During entry of the data into the database the observation was made that, of the large variety of evaluation criteria areas and items, many were substantially equivalent, differing only in nomenclature. In order to rationalize the data the printed output of the original data base was examined, synonomous areas and items were identified, and the most frequently used term for that area or item was added to a parsimonious set of area and item names. A copy of the original database file was made and this copy was edited by substituting synonomous area and item names in conformity with the parsimonious set of

criteria. A tabulation of the original areas, their frequency of use, and the substitutions used is presented in appendix A.

Proceeding with the revised dataset the following statistics were collected:

a. <u>Use of each area</u>. The total number of instances of the use of each area in the sample and percentage proportion of usage in the sample were recorded.

b. <u>Use of each Item</u>. The total number of instances and percentage uses of each item in the sample and also within each area were recorded.

These statistics were used to create a further dBASE II database from which were listed the areas and items in relative order of usage frequency, in order to observe the most popular areas and items and the relative strengths of their popularity. The result of this processing provides a hierarchical list of areas (tabulated in Appendix B), and their relative items (Appendix C), indicating the historically based relevance of those areas and items to the source selections of the population sample. Therefore, if the assumption that past experience in the selection of source selection evaluation criteria is relevant to the determination of criteria for new programs, the list also provides a prioritized clue to the criteria which should be examined for inclusion in any new program.

In order to determine the frequency of occurrence of each area, the respective area fields of each record in the original database were sorted into alphabetical order and output in vertical columns placed side-by-side across the printer page. This had the advantage of not only arranging the areas into easily identified groups with the relative frequency of the most common area names easily observable, but also clearly showed the numbers of source selections that used only two areas, three areas, four areas, and five or more areas in the evaluation criteria.

The structured listing, while presenting the program manager with a comprehensive selection of possible criteria together with their relative probability (historically speaking) of being useful to him, is not a particularly useful decision support aid as it stands because it simply presents a large volume of information in an ordered form rather than presenting selective information tailored to his particular requirements. The decision maker needs to be able to call only that information which is clearly relevant and important to the decision at hand and discard and suppress any superfluous or trivial information which may serve to cloud the issue rather than support a decision.

The process of synthesis of the decision-supporting information requires an input from the decision maker to define the decision parameters and thus give the decision support system direction. The input which the program

manager has to support his source selection evaluation criteria decision was described earlier (Figures 3 and 4).

The original dataset included five fields per record refered to as attributes of the system which was the subject of the source selection. The attributes of the system serve to record a keyword description of the type of procurement activity, including the phase of the program, the type of equipment or service, and the type of contract.

The aggregate of the attributes of all the systems in the dataset may be considered to be members of a set. Furthermore, if the membership of the set is sufficiently comprehensive, any new system will very likely be describable in terms of a selection of some members of the set, a specific subset of attributes.

A subset of this set would be associated with each system in the dataset, and each such subset would also be associated with a subset of the set of source selection evaluation criteria. Considering the dataset as a whole, the attributes could be regarded as independent variables and the respective evaluation criteria as dependent variables. If a causal relationship between the independent and dependent variables could be shown to exist, then there would be a basis for the postulation that given any subset of attributes a set of evaluation criteria could be predicted. In other words, if a new system can be described with a subset of the set of attributes derived from the

historical data, then a set of probably appropriate evaluation criteria could be determined based solely on the historic data. This would provide the core of a worthwhile decision support tool.

Statistical techniques are available which can assess the probability of a causal relationship existing between two or more nominal variables. These techniques fall into the realm of analysis of cross-classified categorical data and are well described by various texts including Siegel (32), Reynolds (30), and Fienberg (19). Briefly, the procedure consists of the constructing a contingency table in two or more dimensions and using various statistical tests, such as chi-square or the contingency co-efficient, to assess the degree of association between the variables.

However, these techniques only allow for the possibility of one value for each variable to occur in any one observation. That is, for any observation in the data set, the possible values for any variable must be mutually exclusive. The data set constructed for this thesis does not comply with those constraints if the system is taken as a variable and the system attributes as values of that variable. The variable "System" will have several values simultaneously in each observation of the dataset. A methodology to determine the association or otherwise between the values of the variable "System" and the

evaluation criteria by considering all attributes of the system together would be desirable to take account of any modifying influences between the attributes in order to moderate the indication of false associations occurring as a result of relationships between the values of the variable "System". A search of the literature has failed to reveal any methodology which specifically approaches this problem.

<u>Heuristic Methodology</u>

There is, however, the possibility of constructing a less rigorous heuristic methodology for analysis of the data and subsequent decision support. The method of description of each system must be modified to permit adequate discrimination of a system by selecting a value for each variable in a set of variables which collectively describe the system. Each variable should have a limited, and mutually exclusive set of values from which one must be selected for each observation in the data set.

To illustrate the procedure consider five possible variables which may be used to describe a system. They are:

a. The phase of the acquisition cycle, having the values;

   (i) conceptual,

   (ii) demonstration and validation,

   (iii) full scale development, or

   (iv) production and deployment.

b. Major system, a dichotomous variable with values yes or no determined in accordance with AFR 70-15 or other appropr'al authority.

c. The class of weapon system with values, for example:

(i) aircraft,

(ii) missile,

(iii) vehicle,

(iv) ground radar, etc.

d. The scope of the procurement with values, for example:

(i) complete system,

(ii) spare part,

(iii) component breakout,

(iv) integrated subsystem (eg. radio, ECM, navigational aid, software),

(v) ground support equipment,

(vi) maintenance services, etc.

e. The class of contract to be awarded, for example;

(i) firm fixed price (FFP),

(ii) cost price incentive firm (CPIF),

(iii) cost price award fee (CPAF), etc.

The actual variables and their respective value sets used in any specific decision support system would need to be selected following careful assessment of the most important factors bearing on the selection of evaluation criteria for the type of systems normally procured by the particular agency employing the DSS. The preceding variables are presented purely as a illustration of the procedure and in no way suggested as being appropriate for any instance.

Having assigned an appropriate value to each System variable for each observation in the dataset, one may now construct a series of conventional contingency tables for each system variable against a variable (say Areas) which has as its values the evaluation criteria areas for the observations in the data set. If each observation has five criteria areas (including possibly one or more null entries, that is, some observations may have for example only three evaluation areas and thus would have two null or "No Criteria" entries) then the totals of the rows and columns of the contingency table will be greater by a factor of five than would be the case if there was only one value of the variable "Areas" per observation in the dataset. The cells of the contingency table could therefore be normalized by dividing throughout by five and then percentages calculated for each cell in the normal way.

A hypothetical construction of such a table is given as Table I. In this case the system variable is the "Phase of the Acquisition Cycle" with its five possible values as illustrated earlier. The other variable is "Areas" with seven possible values;

a. Technical,

b. Operations,

c. Management,

d. Production,

e. Logistics,

f. Cost, and

g. No Criteria.

Assume that this hypothetical dataset contains 100 observations (that is, 100 different systems which underwent the source selection process) and each observation contained exactly five evaluation criteria areas (of which one or more may have been null or no criteria where the system was evaluated using less than five evaluation criteria areas). Into each cell of the table is entered the number of records of the data set for which the relevant values of each variable co-exist. For example, there may be 22 systems out of the total of 100 which were in the "conceptual" phase of the acquisition cycle," and of those 22 they all used the criteria "Technical" and "Cost," only five used "Operations," 20 used "Management," two used "Logistics," and none used "Production." It follows then that there were

TABLE I

Example Contingency Table

Variable: Acquisition Cycle Phase

Phase of Acquisition Cycle / Areas	Conceptual	Demonstration and Validation	Full Scale Development	Production and Deployment
Technical 19.2%	22 (4.4) 20.0%	18 (3.6) 18.0%	24 (4.8) 19.2%	32 (6.4) 19.4%
Operations 11.2%	5 (1.0) 4.5%	16 (3.2) 16.0%	21 (4.2) 16.8%	14 (2.8) 8.5%
Management 15.8%	20 (4.0) 18.2%	15 (3.0) 15.0%	23 (4.6) 18.4%	21 (4.2) 12.7%
Production 11.2%	0 (0) 0%	5 (1.0) 5.0%	18 (3.6) 14.4%	33 (6.6) 20.0%
Logistics 9.6%	2 (0.4) 1.8%	10 (2.0) 10.0%	6 (1.2) 4.8%	30 (6.0) 18.2%
Cost 20.0%	22 (4.4) 20.0%	20 (4.0) 20.0%	25 (5.0) 20.0%	33 (6.6) 20.0%
No Criteria 13.0%	39 (7.8) 35.5%	16 (3.2) 16.0%	8 (1.6) 6.4%	2 (0.4) 1.2%
Totals	110 (22.0) 100.0%	100 (20.0) 100.0%	125 (25.0) 100.0%	165 (33.0) 100.0%

39 blank "areas" fields within those 22 observations of the data set and they are recorded in the "no criteria" cell. When the counts for each cell are entered the table may be normalized by dividing throughout by five because there were five values for "Areas" recorded in each observation of the data set. Now the total sum of all the cells of the table is 100 which equates to the number of records in the data set as is normal for a standard two-dimensional contingency table. The values in the table may also be expressed as percentages by dividing throughout by the number of records in the data set if that is the preference of the user.

Precisely the same procedure for developing a contingency table could be followed for each of the other "System" variables, resulting in a set of contingency tables. Each of the contingency tables may then be examined for statistically significant association between the system variable and the evaluation criteria areas used. The statistical analysis could be very easily accomplished using standard analysis techniques such as those described by Fienberg (19), Siegel (32), or any other text on the analysis of cross-classified categorical data and with the aid of one of the several statistical software packages such as SPSS (Statistical Package for the Social Sciences) that are commercially available.

The aim of the statistical analysis should be to determine whether there is any association between the

evaluation criteria and each system variable. If there is, then the system variable may be included in the model for decision support, but if there is not determined to be statistically significant association for any particular system variable, then that variable should probably be discarded as not being a useful description of a system. The choice of one or several of the measures of association applicable to multivariate tables of nominal data is a matter for the personal preference of the user and will not be explored here.

Consider now the case of a new system which is being procured and subject to source selection procedures. This new system, in exactly the same manner as each of the systems in the data set, could be described by selecting a value for each of the previously defined system variables. These values may be used as labels for columns in a table such as presented in Table II. The rows of the table may be labelled with the possible values of the variable "areas" in identical manner to the set of contingency tables. Into the cells of each column of this table may be transcribed the values from the cells of the column of the same name in the appropriate contingency table. We now have a table which gives an indication of the relative frequency of use of criteria in previous source selections for systems with one of the characteristics of the new system. An aggregation of these historical associations should provide an indication,

TABLE II

Example Decision Support Prediction Table

New System / Areas	Phase Concept	Major System Yes	Class Missile	Scope Complete	Contract CPIF	Total
Technical	22 (4.4) 20.0%					
Operations	5 (1.0) 4.5%					
Management	20 (4.0) 18.2%					
Production	0 (0) 0%					
Logistics	2 (0.4) 1.8%					
Cost	22 (4.4) 20.0%					
No Criteria	39 (7.8) 35.5%					
Totals	110 (22.0) 100%					

suitable for implementation within a decision support system, of which criteria are likely to be relevant in the source selection process for a new system with these characteristics. The simple summation of the cells in each row will give figures for each criteria which reflect the frequency of use of that criteria relative to the other possible criteria in the historical data. Thus the criteria may be ranked in order of past usage and indicate a priority for consideration by the program manager for use with his new system. Criteria with very low scores may even be excluded from presentation by the decision support system for consideration by the program manager. The score of the "no-criteria" row indicates the degree to which the past source selections used less than five areas in their criteria and thus a high score would signify to the program manager that he probably should also consider selecting fewer criteria for the new system evaluation.

Assumptions

The procedure outlined is based on some rather broad assumptions as is the case with many useful heuristic tools. However, the limitations imposed by these assumptions may be reduced by careful design of the DSS and by user awareness of the assumptions and recognition of the role of a DSS as a decision support tool rather than a decision making system.

The first and major assumption is that of independence between the various descriptive system

variables. For a data set gathered to provide the basis for a specific DSS implementation, the systems analyst could test the system variables proposed for use and hopefully only incorporate those which were both significant to the selection of evaluation criteria and yet not themselves significantly associated.

Success in the selection of mutually independent system variables will reduce the limitations of the second assumption that spurious associations indicated between the variables in each contingency table are not significant. Prudent selection of the measures of association by the analyst implementing the DSS will reduce this danger.

A third assumption is that the data set reflects successful source selection processes and some measure of the eligibility of a particular source selection for inclusion in the data set would be desirable. This may, in practice, be an extremely difficult factor to evaluate but its importance is obvious. Unless some sort of feedback mechanism was built into the DSS to record the success or otherwise of the decisions made, the quality of decisions will tend toward a mean but not improve although, of course, they may be made more quickly.

Limitations on the Research

The author was unfortunately not able to pursue the validation of the heuristic methodology to the degree that

he desired. The prime reason was that he did not have access to the level of information required to assign values to the system variables for the dataset. To proceed further with a relatively arbitrary assignment of values, based on inadequate information, and then draw conclusions from the results would be simply futile and probably misleading. The required level of access to the necessary source selection information could probably only come in conjunction with a formal research directive from an appropriately high management level within the relevant Command.

IV. Findings

The Problem

The Source Selection Process is almost invariably a complex, time consuming, and costly process. The high cost is largely a function of time and thus one method of significantly reducing costs is to streamline the process. An avenue being actively pursued is computerization of some areas of source selection activities, notably office automation, since a large volume of work is typically clerical in nature (5, 6, 17), and program managers' decision support since many of the decisions are complex (12, 13, 31). The aim of this research effort was to further aid in the provision of decision support for program managers during the determination of proposal evaluation criteria for source selection.

The Research Question

Given that the selection of appropriate evaluation criteria in any source selection is not only difficult and time consuming, but also crucial to the success of the project, the question is whether a decision support system designed to aid the program manager in this task is feasible.

The Data

The database used for the research was drawn from the Source Selection Plans of 81 source selections processed by Air Force Systems Command, Aeronautical Systems Division (ASD) since 1971. Restrictions imposed by the Source Selection Sensitive classification of the data were non-disclosure of sensitive information in this report, and denial of access by the author to further sensitive system information. Thus the research was halted at the point where a higher level of security clearance was required to proceed.

The data was intended to serve only as a base from which to determine the feasibility of the ideas to be introduced, not as an information source for an operational decision support system. As such, it needed only to be representative of real world data, not a total population or even a strictly random sampling.

The Database Management System

Manipulation of the data was achieved using the relatively simple, convenient, and economical relational database management system for microcomputers called dBASE II (copyright by Ashton Tate, Culver City CA). The system proved to have significant limitations, principally in terms of capacity and speed of processing, which would render it unlikely to be suitable for use in an operational DSS, but for the purpose of examining this data set it was adequate.

Observations from the Data

Several observations were made from the data during manual entry into the database and prior to any processing. The observations related to the general form of evaluation criteria.

Fields were reserved in the database file to record five criteria areas per record (a source selection plan or system undergoing source selection) and four criteria items per area. The space reserved for areas proved to be adequate in all except a very few cases and those plans which used more than five evaluation areas either split an otherwise common area into two or added an area or two which were unique to that particular system and thus would likely have significance in a DSS which was concerned with highlighting frequency of useage. The space reserved for items, limited by the dBASEII capacity was often insufficient and thus detailed analysis of items was not possible.

A second observation was that there was considerable variety in the method of presenting the areas and items in the plans. Many plans simply listed them or presented them as paragraph or sub-paragraph headings making up a form of qualified and amplified listing. A few plans included the presentation of the criteria in a narrative form where the author was compelled to cxtract key words from a paragraph

or try to capture the essence of the criteria as described with one of the more commonly used terms. This was a rather subjective process, but with little alternative.

A further observation was that many of the criteria, particularly areas, used a variety of terms to refer to essentially the same thing. For example, "manufacturing" and "production" were both used but the author could not, with the information available to him, determine any difference in meaning between the two. As will be discussed later, the rationalization of all synonomous terms into a parsimonious set of criteria names produced a very much reduced number of different criteria which, had they been used in the original plan, would have produced much more marked similarity between the plans.

Even without the rationalization of the area names there was observed to be regular similarities among the plans, particularly when arranged in rough chronological order. The similarities suggest two likely possibilities. Either reference is commonly made to the files of previous source selections during the determination of source selection criteria as was discussed on pages 37 and 39 and corroborated by a professional in the field, or plans are commonly prepared by reference to a standard handbook, model, or authority. Whichever is the case, a successful DSS could supercede both procedures.

Following entry of the data into the database some summary statistics were able to be gathered. The database area fields were sorted into alphabetical order and printed out in vertical columns placed side by side across a wide page. From this printout a simple count showed that 64 (or 79%) of the 81 plans in the dataset used less than five criteria areas and of those, 24 (30% of the dataset) used less than four areas. Consequently, the assumption that five criteria areas are normally adequate to cover the requirements of any source selection situation appears reasonably valid.

The data were then examined for the frequency of occurrence of each criteria area. There were 73 different areas used in the set of 81 plans. Of those 73 the most commonly used criteria areas were:

Area	Occurrence in 81 Systems	%
Cost/Price	60	74
Technical	53	65
Management	41	51
Logistics	20	25
Life Cycle Cost	15	19
Operational	8	10

The remaining areas were all used in less than 10% of instances and forty seven areas were used only once. However, as stated previously, many of the areas used infrequently appeared, given the limited information

available to the author, synonomous with one of the more popular terms. Further, some areas were really the conjunction of two areas, as in the cases for example of "Operational/Technical," "Logistics/Operations," and "Technical/Operational Utility."

A very few areas did not easily fall into any common category and whether or not their importance was sufficient in the source selection for which they were used, to warrant inclusion as an exclusive area could not be satisfactorily determined by the author from available information. The criteria "Weight" and "Test-in-Container Capability" were examples of unique criteria areas in the dataset which the author questions may have more appropriately been evaluated as highly weighted items under the area of "Operations." But supportable judgement on these matters could only be made with the benefit of an indepth knowledge of the system.

The approach then taken was to examine the data in relation to those criteria which are prescribed or mandatory according to Federal or Defense regulations.

The Federal Acquisition Regulations (41:15-20) specifically states that "price or cost to the Government shall be included as an evaluation factor in every source selection." There is thus no doubt that "Cost/Price" should be included in the set of mandatory evaluation criteria. The source selections in the dataset largely complied with that requirement although a significant number (19%)

included the cost/price evaluation under the area name of "Life Cycle Cost."

The only other criteria that was noted to be specifically prescribed for use was that of "Contractor Past Performance" as directed by both DODD 5000.34, Defense Production Management (37) which states;

> Contractor past performance (to the extent that it has a bearing on the concept involved), potential to execute the production program, and demonstrated production management capability shall be among those factors . . . evaluated . . . in the source selection

and Interim Message Change (IMC) 79-1 to AFR 70-15/AFSC Supplement 1 which implemented the use of Relevant Past Performance in all formal source selections.

However, the interpretation applied to that directive by ASDP 800-7 (43:5) is that past performance in this instance is considered a type of evaluation measurement such as understanding the problem, soundness of approach, compliance with requirements correction potential (impact on design), effect on schedule, and unique solutions. That position is further reinforced by the latest publication concerning source selection, AFR 70-15, issued on 22 February 1984. Specifically, it states that past performance may be both an assessment criterion and a general consideration, but does not suggest that it should be considered as a specific criterion.

Thus one would not expect to see "Contractor Past Performance" as an evaluation area, but as a measure of

evaluation for all areas. This is supported by observation of the dataset since only 7% of the source selections used "Contractor Past Performance" as an area, but most mentioned it as a factor in the explanatory narrative of the source selection plan. One must also note that the entire dataset is composed of plans which were formulated prior to the publication of the more explicit guidance contained in the current issue of AFR 70-15. In view of the very recent guidance contained in AFR 70-15, Past Performance does not now strictly qualify for inclusion in any set of specific criteria.

The review of the regulatory publications revealed that certain evaluation areas take on the qualification of recommended criteria simply because of their repeated use as examples of appropriate criteria in numerous publications at all levels. Those criteria areas are:

a. Technical,

b. Operations,

c. Logistics,

d. Management,

e. Production, and

f. Costs.

The data generally supports the view that these six areas should be included in a set of recommended criteria. They were the most frequently used criteria with the exception that Life Cycle Cost was more common than

Operations. The author feels that life cycle cost could reasonably be considered a sub-part of the more generic term Costs. Then the Cost/Price area would have, with the substitution of cost for life cycle cost, tallied 75 out of 81 systems or 82% of the source selections in the dataset.

In summary, the only compulsory area is Cost/Price and the five next most common and therefore recommended criteria areas are Technical, Operations, Logistics, Management, and Production. The remainder of the criteria in the dataset would then be relegated to the category of system specific criteria.

A closer examination of the dataset however shows that the majority of the now system specific criteria are very closely related to, subparts of, or synonomous with, one or other of the compulsory or recommended criteria. In order to rationalize the criteria sets the system specific criteria in the dataset were replaced with the appropriate, more generic term in the compulsory and recommended sets. This substitution was a somewhat arbitrary process but done with some care by the author and the substitutions are listed in Appendix A for the reader to make his own assessment.

Analysis of the new dataset will not, of course, change the membership of the set of compulsory criteria since that was determined solely by reference to regulation.

The incidence of use of each of the criteria areas in the new dataset is as follows (also repeated at Appendix B):

AREA	INCIDENCE	% USAGE
Contractor Capability	6	7
Contractor Past Performance	6	7
Coproduction/Offset	2	2
Cost/Price	75	92
Logistics	40	49
Logistics/Management	1	1
Logistics/Operations	1	1
Management	57	70
Management/Production	8	9
Operations	24	29
Production	12	14
Schedule	8	9
Technical	66	81
Technical/Operations	6	7
Technical/Production	1	1

Interestingly, the order of descent from most commonly used criteria to least commonly used has not changed for the six areas included in the set of recommended criteria. Particularly, when those source selections that combined two criteria into one area are included in the count of useage of the recommended set criteria then their position is well consolidated. The two leading criteria in

the recommended set, Technical and Management, were then used in 89% and 82% of the source selections respectively, and they lead the other criteria by a substantial margin. Indeed, considering the types of procurements for which ASD would normally expect to contract out, one would suggest that Technical and Management are intuitively very strong candidates for use in virtually every source selection for that Division. The remaining criteria in the recommended set are obviously still common enough to be important but there are few criteria outside this set that appear sufficiently unique as to not be adequately covered by the general criteria within the recommended and mandatory sets. For example, Contractor Capability and Contractor Past Performance, while being both extremely important elements in an evaluation are probably more useful as measures of items in each area than criteria areas themselves.

The criteria areas thus reduce to a very manageable number which could be used both as a "standard" set of criteria for a program manager to select from, and also for inclusion in the heuristic model for the decision support system described in Section III.

The results, in summary, are:

Mandatory Criteria Set

Cost/Price

Recommended Criteria Set (in descending order of useage frequency):

Technical
Management
Logistics
Operations
Production
Schedule
Coproduction/Offset.

An examination of the items under each area revealed a much greater range, as would be expected with the more explicit definition an item entails. Although many items appeared, as was the case with the areas, to have several different terms referring to substantially the same thing, any attempt at substitution and rationalization, as was done for the areas, would have been difficult to validate. A list of items under the heading of each area and the number of source selections in which each item was used is given in Appendix C. This appendix should be read in conjunction with Appendix B to see the relative rate of usage of items between areas and within the dataset as a whole.

As an example of the use of the appendices consider the areas Contractor Capability and Cost/Price. Contractor Past Performance, as an item under the area of Contractor Capability, was used three times in the six occurrences of Contractor Capability, or 50% of the times that Contractor

Capability was used as an area. Completeness, on the other hand, was used 43 times as an item of Cost/Price, but that equates to only 43/75 or a 57% usage rate. While some items were used more frequently than others there was no clear set of significantly more popular items as there was with the areas.

Further, with the very large range of items and the high proportion of single use items, one can conclude from simple visual inspection that there will be no statistically significant or meaningfull associations between system attributes and items. There is the possibility that, with in-depth knowledge of each system, the item names could be rationalized or standardized in nomenclature sufficiently to observe some degree of association between items and their system's attributes. But such a study would be extremely involved and most likely impractical. If it could be achieved then a third dimension (items for each area) could be added to each of the tables of the heuristic model previously discussed.

One final observation made from the examination of items was the use as specific criteria of factors referred to by AFR 70-15 as assessment criteria. Again recall that the entire dataset was pre-issue of the current AFR and the more explicit explanations contained there-in may produce more consistent area and item selection in the future.

The range of items in each area was very large and no

common patterns were evident. There was an overwhelming majority of single use items which negated any requirement to search for associations between system attributes and criteria items. The incorporation of items into a decision support system is therefore considered infeasible.

V. Summary, Conclusions, and Recommendations

Background

The acquisition of a weapon system will involve the procurement by contract of materiel and services at numerous points during all phases of the acquisition cycle. When a choice between competing contractors must be made a process called source selection is used. Source selection involves the evaluation of proposals submitted by contractors and selection of the offer considered most advantageous to the government.

The evaluation of proposals is achieved by scoring each proposal on the basis of a set of predetermined evaluation criteria. The criteria are defined and explained in a pre-solicitation document called the Source Selection Plan. Rules and guidance for the conduct of source selections and the preparation of source selection plans are contained in several Federal, Defense and Service publications. However, the source selection evaluation criteria are required to be specifically tailored to the needs and characteristics of the system or subsystem being procured, and guidance on the selection of appropriate criteria is vague and fragmented.

Research Problem

The source selection process is usually long and costly and the determination of evaluation criteria is often one of the hardest tasks to be accomplished. Action is being taken to reduce the duration and cost of the source selection process by the introduction of office automation and decision support systems to some agencies. This research is aimed at further assisting in the development of decision support systems by examining the decision processes involved in the determination of source selection evaluation criteria.

Research Question

The research question is whether a decision support system designed to aid in the determination of source selection evaluation criteria is feasible.

Decision Process

Investigation revealed that guidance in the determination of evaluation criteria comes from several sources including regulatory publications, handbooks, past experience, intuition, and, in particular, the files of past source selections. In many cases the decision as to which criteria to use in a given source selection is a semi-structured process which takes the example of a previous similar source selection and modifies the criteria as necessary and dictated by the circumstances of the current

procurement. The potential for decision support lies in the possibility of aggregating the wealth of past experience contained in the decisions made to select criteria for previous source selections.

Methodology

The methodology adopted to determine the feasibility of a decision support system for the determination of source selection evaluation criteria was to examine a comprehensive set of source selection plans used by an acquisition agency on procurements over about one decade.

The first step was to assess the extent to which the decision process was programmed by determining which criteria, if any, were prescribed by regulation and thus belonged to a set of mandatory criteria.

The second step was to determine whether there was any relationship between the character of the system being procured and the source selection criteria used for contractors' proposal evaluation. The procedure envisaged to accomplish this was to describe the weapon system by using a set of key-word descriptions or attributes which collectively define those characteristics of the system that may influence the evaluation criteria used. These attributes of each system and the criteria used by each source selection were then to be used to construct a contingency table of cross-classified categorical data which could be analyzed with a commercial computer statistical

package to assess the degree of association between the system attributes and the criteria. If a subset could be drawn from the set of attributes to describe a new system then that subset could be used to indicate the criteria which should be considered for use in the source selection for the new system. These criteria would be added to any criteria recommended for consideration by any other source, regulations or handbooks, to form a set of recommended criteria.

However, the author was unable to find any published methodology for measuring the degree of association, if any, between the attributes and the criteria. Conventional analysis of cross-classified nominal data does not allow for the situation where a variable may take on more than one value for a given observation in the sample population. Consequently, the author was driven to develop a less rigorous, heuristic methodology for the basis of a decision support system.

The heuristic is presented as a framework upon which a decision support system could be built. The method consists, briefly, of describing each system in the historical dataset by assigning one from a set of values for each of several variables which collectively serve to define the system characteristics that affect the evaluation criteria. For each of these variables a contingency table is constructed which can be analyzed using conventional

cross tabulation techniques to determine the degree of association between that system characteristic and the evaluation criteria. A new system may be described in terms of values of the attribute variables in a similar manner to that envisaged and described for the original methodology. A table may then be constructed matrixing those attribute values against all possible criteria. The frequency counts for each attribute variable value may be transferred from the appropriate contingency table of the historical dataset to the cells of the newly constructed table. The sum of the frequencies of each criteria will then provide an indication of the relative historical usage of each criteria in systems with those collective values of the attribute variables.

Data

The dataset was drawn from Source Selection Plans since 1971 for source selections conducted by Air Force Systems Command Aeronautical Systems Division and consisted of the evaluation criteria in terms of area and item names used for each of 81 source selections.

The author attempted to define system attribute variables and assign values to those variables for each system in the dataset, but found that the information contained within the plans was insufficient to complete that task to any reasonable level of satisfaction. Further, due

to the circumstances of the author, the sensitive nature of source selection material, and the security classification of many pertinent details of new weapon systems, access to the necessary level of information was not available. Thus, a test of the heuristic methodology was not possible.

The research was therefore directed toward the evaluation criteria to assess at least its suitability for incorporation into a DSS using the heuristic method.

Findings

The range of criteria areas used in the sample source selection was found to be large; far too large to be effectively used in a DSS. However, a relatively few criteria had a high rate of usage while a very large number had a very low rate of usage. Further examination showed that most of the latter class of criteria were synonomous or very nearly so with one of the criteria in the high frequency set. When the dataset was modified by substituting the most co' non term for each criteria the number of different criteria reduced to about 10 which is a manageable number for a DSS. While the modification of the dataset was a somewhat arbitrary and subjective process, and thus open to some criticism, the suggestion that a relatively small set of criteria areas to choose from would cater for the vast majority of systems is intuitively appealing. There is not likely to be significant practical difference between the use of slightly different

nomenclature at the area level of criteria.

The range of items in each area was also large and no common patterns were evident. In the case of items however, substitution of more common names for similar ones, as was done for the areas, could not be justified. Further, since there was an overwhelming majority of single incidence items, there was no point in trying to establish the existence of any associations between system attributes and criteria items.

Conclusions

The aim of the research was to determine the feasibility of a decision support system to aid in the determination of source selection evaluation criteria. The overall conclusion drawn in regard to that research question is that, as far as the research was able to proceed given the constraints of access to classified information, the development of a decision support system which will use past source selection data to aid in the determination of source selection evaluation criteria for a new system is feasible.

The conclusion of feasibility however, requires qualification. Firstly, the more rigorous data processing methodology originally envisaged is not possible, as developed, using currently available statistical techniques. Secondly, the heuristic methodology as described is feasible in that the number of criteria is manageable and the

processing is computer programmable. However, the feasibility of describing each weapon system in terms of values of a small set of attribute variables has not been tested and will only be testable with access to the required level of information. Further, and subsequent to the selection of attribute variables, the association, if any, between the attribute variables and evaluation criteria must be established. Thirdly, the criteria items, and also therefore factors and sub-factors, exhibited insufficient likelihood of association with attribute variables to be considered suitable for inclusion in the DSS model.

Further conclusions which were drawn from the analysis of the data were:

a. Mandatory Criteria. Only one criterion area, that of Cost/Price, could undeniably be shown to belong to the set of mandatory criteria as determined by reference to regulatory publications. Past performance, while prescribed as a factor for evaluation in source selections (44,9), is considered to be an assessment criteria and/or a general consideration, but not a specific criteria area of the type to be included here.

b. Recommended Criteria. The criteria areas Technical, Management, Logistics, Operations, and Production are candidates for inclusion in

a set of recommended criteria which would provide the rows for each contingency table for the heuristic methodology.

c. System Related Criteria. A few criteria were obviously not of the general nature of the recommended criteria and thus could probably be turned on or off dependent on the values of suitable dichotomous variables. Coproduction/Offset was one example which is clearly only going to be applicable in a select number of instances and thus could be assigned to a set of system related criteria.

The observation that very few of the source selection plans in the dataset used more than five criteria areas leads to the conclusion that five areas should be the maximum used for new systems except in unusual circumstances. In the same vein, those areas included in the criteria for a given system should be able to be drawn from a relatively small (possibly 10 or less) set of standard criteria. Since the areas are normally subdivided into items, the area name is a rather broad indicator and the author concludes that the following set would probably satisfice as a minimum for a complete set of recommended criteria:

a. Technical,

b. Management,

c. Logistics,

d. Operations, and

e. Production.

Similarly, a set of system related criteria, based on the observation of the dataset used for this research would be:

a. Coproduction/Offset,

b. Test,

c. Schedule, and

d. Contractor Past Performance.

A conclusion was also drawn that frequently, plans had been prepared by either reference back to a previous plan or reference to the same other source that a previous plan had been copied from. In many cases there was the appearance of a tendency to change criteria names in nomenclature, but not in meaning, when preparing new plans from old, possibly to present some semblance of originality.

Recommendations

The results of the research lead to the major recommendation that the research should be continued in the pursuit of a decision support system for the determination of source selection evaluation criteria. In conjunction with that recommendation, the following recommendations are also made:

a. Since access to classified data will be

involved in future research, the impetus and authority to conduct the effort should originate at such a level as to ensure adequate access to the necessary information.

b. The determination, test, and validation of suitable system attribute variables will be a major undertaking and for that reason should be commenced with the declared aim of implementation of a specific decision support facility on successful completion of the research.

c. Attention should be paid to the nature of the final DSS and its interface with existing or planned office automation systems and other decision support aids with the aim of constructing the database for the research to be compatible with future requirements. The capabilities of currently available microcomputer database management systems will probably not meet that requirement or permit sufficient growth potential.

d. The quality of the historical evaluation criteria used for the database should be assessed by measurement of the success of the source selection process in each case to ensure that future decisions are not influenced adversely by bad past decisions.

Appendix A: Area Frequencies and Substitutions

Area	Usage	%	Modified Area
ABILITY TO MEET SCHEDULE	1	1	SCHEDULE
ADEQUACY OF DESIGN	1	1	TECHNICAL
ADEQUACY OF PROGRAM	2	2	MANAGEMENT
COMPLIANCE WITH SPECIFICATION	1	1	OPERATIONS
CONTRACTOR CAPABILITY	5	6	CONTRACTOR CAPABILITY
CONTRACTOR PAST PERFORMANCE	6	7	CONTRACTOR PAST PERFORMANCE
COPRODUCTION REQUIREMENTS	1	1	COPRODUCTION/OFFSET
COST/PRICE	60	74	COST/PRICE
DESIGN APPROACH	4	4	TECHNICAL
DESIGN CONCEPT	1	1	TECHNICAL
ENGINEERING	1	1	TECHNICAL
FLIGHT TEST EVALUATION	1	1	OPERATIONS
INTEGRATED LOGISTICS SUPPORT	4	4	LOGISTICS
LIFE CYCLE COST	15	18	COST/PRICE
LOGISTICS	20	24	LOGISTICS
LOGISTICS CONCEPTS	1	1	LOGISTICS
LOGISTICS SUPPORT	1	1	LOGISTICS
LOGISTICS SUPPORTABILITY	2	2	LOGISTICS
LOGISTICS/OPERATIONS	1	1	LOGISTICS/OPERATIONS
LOGISTICS/PROGRAM ADEQUACY	1	1	LOGISTICS/MANAGEMENT
LOGISTICS/SUPPORTABILITY	1	1	LOGISTICS
LOGISTICS/SUPPORTABILITY PLANS	1	1	LOGISTICS
MANAGEMENT	41	50	MANAGEMENT
MANAGEMENT & MANUFACTURING	3	3	MANAGEMENT/PRODUCTION
MANAGEMENT APPROACH	3	3	MANAGEMENT
MANAGEMENT EXCELLENCE	1	1	MANAGEMENT
MANAGEMENT/MANUFACTURING	1	1	MANAGEMENT/PRODUCTION
MANAGEMENT/PRODUCTION	1	1	MANAGEMENT/PRODUCTION
MANAGEMENT/PRODUCTION CAPABILI	2	2	MANAGEMENT/PRODUCTION
MANUFACTURING	4	4	PRODUCTION
MANUFACTURING/QUALITY ASSURANC	2	2	PRODUCTION
OFFSET	1	1	COPRODUCTION/OFFSET
OPERATIONAL	8	9	OPERATIONS
OPERATIONAL CAPABILITY	1	1	OPERATIONS
OPERATIONAL UTILITY	6	7	OPERATIONS
OPERATIONAL UTILITY/TECHNICAL	2	2	TECHNICAL/OPERATIONS
OPERATIONAL/TECHNICAL	1	1	TECHNICAL/OPERATIONS
OPERATIONS	1	1	OPERATIONS
OVERALL CAPABILITY	1	1	CONTRACTOR CAPABILITY
PERFORMANCE	1	1	OPERATIONS
PROCUREMENT	1	1	MANAGEMENT
PRODUCTION	2	2	PRODUCTION
PRODUCTION CAPABILITY	1	1	PRODUCTION
PRODUCTION CAPACITY	1	1	PRODUCTION
PRODUCTION/MANUFACTURING CAPAB	1	1	PRODUCTION

Area	Usage	%	Modified Area
PROGRAM ADEQUACY	2	2	MANAGEMENT
PROGRAM ADEQUACY & COMPETITION	1	1	MANAGEMENT
PROGRAM ADEQUACY/SUPPORT	1	1	MANAGEMENT
PROGRAM IMPLEMENTATION	1	1	MANAGEMENT
PROGRAM MANAGEMENT	3	3	MANAGEMENT
PROGRAM MANAGEMENT/PRODUCTION	1	1	MANAGEMENT/PRODUCTION
PROJECT IMPLEMENTATION	1	1	MANAGEMENT
READINESS & SUPPORT	1	1	LOGISTICS
RISK ASSESSMENT	1	1	OPERATIONS
SCHEDULE	7	8	SCHEDULE
SOFTWARE DEVELOPMENT CAPABILIT	1	1	PRODUCTION
SUPPORT	1	1	LOGISTICS
SUPPORTABILITY	7	8	LOGISTICS
TECHNICAL	53	65	TECHNICAL
TECHNICAL ADEQUACY	1	1	TECHNICAL
TECHNICAL APPROACH	3	3	TECHNICAL
TECHNICAL APPROACH/OPERATIONS	1	1	TECHNICAL/OPERATIONS
TECHNICAL COMPETENCY	1	1	TECHNICAL
TECHNICAL EXCELLENCE	1	1	TECHNICAL
TECHNICAL/MANUFACTURING	1	1	TECHNICAL/PRODUCTION
TECHNICAL/OPERATIONAL	1	1	TECHNICAL/OPERATIONS
TECHNICAL/OPERATIONAL UTILITY	1	1	TECHNICAL/OPERATIONS
TEST	1	1	OPERATIONS
TEST & EVALUATION DEMONSTRATIO	1	1	OPERATIONS
TEST-IN-CONTAINER CAPABILITY	1	1	OPERATIONS
USEABILITY/SUPPORTABILITY	1	1	LOGISTICS
WEIGHT	1	1	OPERATIONS

Appendix B: Area Usage for Modified Dataset

Area	Usage	%
CONTRACTOR CAPABILITY	6	7
CONTRACTOR PAST PERFORMANCE	6	7
COPRODUCTION/OFFSET	2	2
COST/PRICE	75	92
LOGISTICS	40	49
LOGISTICS/MANAGEMENT	1	1
LOGISTICS/OPERATIONS	1	1
MANAGEMENT	57	70
MANAGEMENT/PRODUCTION	8	9
OPERATIONS	24	29
PRODUCTION	12	14
SCHEDULE	8	9
TECHNICAL	66	81
TECHNICAL/OPERATIONS	6	7
TECHNICAL/PRODUCTION	1	1

Appendix C: Item Usage for Modified Dataset

Area: CONTRACTOR CAPABILITY

Item	Usage
ABILITY	1
COMMITMENT	1
CONTRACTOR PAST PERFORMANCE	3
EXPERIENCE	3
FACILITIES	1
FINANCIAL, PLANT & EQUIPMENT	2
FUNCTIONAL OPERABILITY	1
MANAGEMENT CONTROL SYSTEMS	3
PROJECT ORGANIZATION	1
PERFORMANCE	1
PERSONNEL	3
PROJECT MANAGEMENT	1
PROPULSION INTEGRATION	1
STRUCTURAL INTEGRITY	1

Area: CONTRACTOR PAST PERFORMANCE

No items used for this area.

Area: COPRODUCTION/OFFSET

Item	Usage
CO-PRODUCTION PLAN	1
CO-PRODUCTION STRUCTURE	1
OFFSET REQUIREMENTS	1

Area: COST/PRICE

Item	Usage
ACQUISITION COST	8
ACQUISITION COST/PRICE	2
APPROACH TO COSTING NEXT PHASE	1
COMPARATIVE ANALYSIS	6
COMPLETENESS	43
CONTRACTOR PAST PERFORMANCE	1
COST ANALYSIS	4
COST TRADE-OFF ANALYSES	1
FINANCIAL RESPONSIBILITY	3
FULL SCALE ENGINEERING DEVELOP	2
LEVEL OF RISK	1

Item	Usage
LIFE CYCLE COST	12
LOGISTICS SUPPORT COST	1
LOGISTICS SUPPORT COST MODEL	1
MOST PROBABLE COST	17
OPERATING & SUPPORT COST	1
OPERATIONS & SUPPORT COST	2
OPTION COSTS	1
PAST PERFORMANCE	2
PAST PERFORMANCES	1
PRICE ANALYSIS	3
PRODUCTION COSTS	2
PROGRAM COST	1
RDT&E COSTS	2
REALISM	1
REASONABLENESS	1
REASONABLENESS & REALISM	51
RESPONSIVENESS TO THE RFP	2
RISK	4
SUPPORT COST	1
SUPPORT EQUIPMENT COSTS	1
TRACEABILITY	3
TRACKABILITY	1
WEAPON SYSTEM COST	1

<u>Area:</u> LOGISTICS

Item	Usage
ADEQUACY OF SUPPORT	3
AVAILABILITY	1
CAPABILITY	1
COMMONALITY	2
COMPATIBILITY WITH SYSTEM DESI	1
COMPLIANCE WITH REQUIREMENT	1
CONTRACTOR LOGISTICS SUPPORT	1
CONTRACTOR SUPPORT	1
DESIGN CHARACTERISTICS	1
ENERGY MANAGEMENT	1
EXPERIENCE	1
EXPERTISE/CAPABILITY	1
FACILITIES	1
FIELD SUPPORT PLANNING	6
GROUND SUPPORT EQUIPMENT	1
GROUND SUPPORT EQUIPMENT PLAN	1
IDENTIFIED RESOURCES	1
ILS ORGANIZATION	1
ILS PLANNING APPROACH	1
ILS REQUIREMENTS	1
INTEGRATED LOGISTIC SUPPORT	1

Item	Usage
INTEGRATED LOGISTICS SUPPORT	4
INTEGRATED SUPPORT PLAN	4
INTEGRATED SUPPORT PLANNING	3
LIFE CYCLE COST	5
LOGISTIC SUPPORT ANALYSIS	3
LOGISTIC SUPPORT PLAN	1
LOGISTICAL SUPPORT REQUIREMENT	1
LOGISTICS CONCEPT	1
LOGISTICS DESIGN APPROACH	2
LOGISTICS DESIGN CONSIDERATION	1
LOGISTICS DOCUMENTATION	1
LOGISTICS ENGINEERING/SUPPORT	1
LOGISTICS INTEGRATION	1
LOGISTICS MANAGEMENT	1
LOGISTICS ORGANIZATION	1
LOGISTICS ORGANIZATION/PERSONN	1
LOGISTICS PLANNING	1
LOGISTICS SUPPORT ANALYSIS	5
LOGISTICS SUPPORT ANALYSIS REC	1
LOGISTICS SUPPORT PLAN	1
LOGISTICS SUPPORT PLANNING	1
MAINTAINABILITY	2
MAINTENANCE CONCEPTS	3
MAINTENANCE PLAN	1
MAINTENANCE PLANNING	1
MAINTENANCE REQUIREMENTS	1
MAINTENANCE SUPPORT	1
MAINTENANCE/MAINTAINABILITY	2
MANAGEMENT INFORMATION SYSTEM	1
OPERATIONAL MAINTAINABILITY	1
OPERATIONAL SUPPORTABILITY	1
PLANS	1
PREOPERATIONAL SUPPORT	3
PREOPERATIONAL SUPPORT PLAN	1
PROVISIONING MANAGEMENT	1
PROVISIONING PLANNING	1
QUALITY ASSURANCE	1
RELIAB/MAINTAINABILITY FORECAS	2
RELIABILITY	1
RELIABILITY & LONGEVITY	1
RELIABILITY & MAINTAINABILITY	5
RELIABILITY FORECASTS	1
SE DEVELOPMENT PLANNING	1
SPARE/REPAIR PARTS PLAN	1
SUPPLY SUPPORT	2
SUPPLY SUPPORTFIELD SUPPORT PL	1
SUPPORT EQUIPMENT	6
SUPPORT EQUIPMENT ANALYSIS	1
SUPPORT EQUIPMENT DEVELOPMENT	1
SUPPORT EQUIPMENT PLANNING	1

Item	Usage
SUPPORT EQUIPMENT REQUIREMENTS	1
SUPPORT REQUIREMENTS	2
SUPPORTABILITY	3
SYSTEM AVAILABILITY	1
SYSTEM FLEXIBILITY	1
SYSTEM PERFORMANCE	1
TECHNICAL APPROACH	1
TECHNICAL DATA	4
TECHNICAL MANUAL REQUIREMENTS	1
TECHNICAL MANUALS	1
TRAINING	5
TRANSITION TO ORGANIC SUPPORT	1

Area: LOGISTICS/MANAGEMENT

Item	Usage
DATA & CONFIGURATION MANAGEMEN	1
INTEGRATED LOGISTICS SUPPORT	1
MANUFACTURING/QUALITY ASSURANC	1
RELIABILITY & MAINTAINABILITY	1

Area: LOGISTICS/OPERATIONS

No item used for this area.

Area: MANAGEMENT

Item	Usage
ABILITY TO MEET SCHEDULES	1
ADEQUACY OF PLANNING	1
ADMINISTRATION	1
APPROACH & ORGANIZATION	8
COMPLETENESS OF PLANNING	1
CONFIGURATION MANAGEMENT	11
CONFIGURATION MANAGEMENT PLAN	3
CONFIGURATION/DATA MANAGEMENT	1
CONTRACTOR CAPABILITY	1
CONTRACTOR PAST PERFORMANCE	3
CONTROL OF COSTS	5
CONTROL PROCEDURES	1
COST MANAGEMENT SYSTEM	1
COST RISK ASSESSMENT	1
CRITICAL PATH SCHEDULE	1
DATA & CONFIGURATION MANAGEMEN	3
DATA MANAGEMENT	9
DEMONSTRATED ABILITY	1
DESIGN TO COST PLAN	1
DUAL SOURCING/BREAKOUT	1

Item	Usage
ENGINEERING MANAGEMENT	1
ENGINEERING PLANNING	1
INFORMATION MANAGEMENT	4
INTEGRATED LOGISTICS SUPPORT	1
INTEGRATED PROGRAM SCHEDULES	1
LABOUR RELATIONS	1
LOGISTICS SUPPORT REQUIREMENTS	1
MANAGEMENT	4
MANAGEMENT & ORGANIZATION	2
MANAGEMENT APPROACH	1
MANAGEMENT CAPABILITY	1
MANAGEMENT INFORMATION SYSTEM	1
MANAGEMENT INTERFACE	1
MANAGEMENT METHODS	1
MANAGEMENT OF SUPPORT FUNCTION	1
MANAGEMENT PLANNING & ORGANIZA	1
MANAGEMENT PROCEDURES	1
MANAGEMENT STRUCTURE	4
MANAGEMENT VISIBILITY	1
MANNING	1
MANUFACTURING	1
MANUFACTURING CAPABILITY	1
MANUFACTURING/OPERATIONS	1
MANUFACTURING/PRODUCTION PLANN	1
MANUFACTURING/QUALITY ASSURANC	6
O&S COST ASSESSMENT	1
ORGANIZATION	4
ORGANIZATION & PLAN	1
ORGANIZATION STRUCTURE	3
ORGANIZATION/PERSONNEL	1
ORGANIZATIONAL STRUCTURE	1
OTHER MANAGEMENT FACTORS	1
OVER AND ABOVE TASK ORDERS	1
OVERALL PROJECT ORGANIZATION	1
PARTS CONTROL PROGRAM	1
PAST PERFORMANCE	1
PERSONNEL	8
PROCEDURES	1
PRODUCIBILITY	1
PRODUCTION CAPABILITY	4
PRODUCTION MANAGEMENT	1
PRODUCTION PLANNING	5
PROGRAM CONTROL	2
PROGRAM MANAGEMENT	5
PROGRAM MANAGEMENT ORGANIZATIO	1
PROGRAM MANAGEMENT PLAN	2
PROGRAM MANAGEMENT PLANNING	3
PROGRAM MANAGEMENT SYTSTEM	1
PROGRAM MANAGER	1
PROGRAM PLAN	1

Item	Usage
PROGRAM PLANS/SCHEDULES	1
PROGRAM PLANS/SCHEDULES/CAPABI	1
PROGRAM REVIEWS	1
PROGRAM SCHEDULES	2
PROJECT MANAGEMENT	3
PROJECT MANAGEMENT EXPERIENCE	3
PROJECT OFFICE ESTABLISHMENT	2
PROJECT ORGANIZATION	1
PROPOSAL COST EVALUATION	1
PROPOSED WORK BREAKDOWN STRUCT	1
PROVIDE & MANAGE ALL RESOURCES	1
QUALITY ASSURANCE	7
QUALITY ASSURANCE SYSTEM	1
QUALITY ASSURANCE/R&M	1
RELIABILITY & MAINTAINABILITY	1
RESOURCE PLANNING	1
RESOURCES	1
RESOURCES & MANUFACTURING CAPA	1
RESOURCES/MANUFACTURING CAPABI	1
SCHEDULE	2
SCHEDULES	8
SCHEDULES & COSTS	1
SPECIFIC EXPERIENCE	1
SUBCONTRACT MANAGEMENT	6
SUBCONTRACTOR	1
SUBCONTRACTOR MANAGEMENT	1
SUPPORT PLANS	1
SYSTEM SAFETY	2
SYSTEM TEST PLAN	2
SYSTEM TEST PLANNING	2
SYSTEMS ENGINEERING MANAGEMENT	1
TECHNICAL	1
TEST & EVALUATION	1
VISIBILITY & CONTROL SYSTEMS	1

<u>Area</u>: MANAGEMENT/PRODUCTION

Item	Usage
CO-PRODUCTION	1
CONFIGURATION MANAGEMENT	3
DATA MANAGEMENT	2
ENGINEERING MANAGEMENT	1
EXPERIENCE	1
MANAGEMENT APPROACH	2
MANAGEMENT CONCEPT	1
MANAGEMENT METHODS	1
MANAGEMENT SUPPORT PLANS	1
MANUFACTURING	2
PRODUCTION CAPABILITY	1

Item	Usage
PRODUCTION CAPABILITY/REQUIREM	2
PRODUCTION MANAGEMENT	1
PROGRAM MANAGEMENT	2
PROGRAM MANAGEMENT ORGANIZATIO	1
PROGRAM MANAGEMENT PLAN	1
PROGRAM/PRODUCTION MANAGEMENT	1
QUALITY ASSURANCE	1
SYSTEM CONFIGURATION CHANGES	2

<u>Area</u>: OPERATIONS

Item	Usage
ABILITY TO MEET REQUIREMENTS	1
AVAILABILITY	2
AVIONICS GROUND OPERATIONS	1
COMPLIANCE WITH RFP	1
CONCEPTUAL UNDERSTANDING	1
CONTRACTOR TEST RESULTS	1
DESIGN	1
DESIGN APPROACH	1
ENROUTE PERFORMANCE	2
FLIGHT TEST PROGRAM	1
GOVERNMENT LABORATORY TESTING	1
GROUND OPERATIONS	1
GROUND TEST PROGRAM	1
INFLIGHT PERFORMANCE	1
MISSION PERFORMANCE	2
MISSION PRODUCTIVITY	1
MISSION SCENARIOS & THREAT	1
MISSION SUITABILITY	1
OPERATIONAL CONCEPTS	1
OPERATIONAL CONSTRAINTS	1
OPERATIONAL PERFORMANCE	1
OPERATIONAL SAFETY	2
OVERALL EFFECTIVENESS	1
PERFORMANCE	3
PRODUCTIVITY	1
QUALITY ASSURANCE	1
RELIABILITY & MAINTAINABILITY	6
SCENARIO SOLUTIONS	1
SEARCH & RESCUE PHASE	1
SOFTWARE VERIFICATION	1
SOUNDNESS OF APPROACH	1
SUBSYSTEM/SYSTEM INTEGRATION	1
SUPPORTABILITY	3
SURVIVABILITY & VULNERABILITY	1
SYSTEM CAPABILITY	1
SYSTEM OPERATIONAL CONCEPT	1
TECHNICAL PROPOSALS	1

Item	Usage
TECHNICAL PUBLICATIONS	1
TEST PLANNING	1

<u>Area</u>: PRODUCTION

Item	Usage
ABILITY TO MEET PRODUCTION REQ	2
ABILITY TO MEET SCHEDULES	2
BUSINESS PLAN	1
CRITICAL/LONG LEAD TIME ITEMS	1
ENERGY EFFECTIVENESS	1
FACILITIES	1
MANAGEMENT SYSTEM	1
MANAGEMENT SYSTEMS & CONTROL	1
MANUFACTURING CAPABILITY	1
MANUFACTURING CAPACITY/CAPABIL	1
MANUFACTURING PLANNING	1
MANUFACTURING TECHNOLOGY	1
ORGANIZATION	1
ORGANIZATION STRUCTURE	1
PERSONNEL	1
PRODUCIBILITY	1
PRODUCTION CAPABILITY	1
PRODUCTION CAPABILITY REVIEW	1
PRODUCTION MANAGEMENT SYSTEM	1
PRODUCTION PLAN	1
PRODUCTION PLANNING	5
PROGRAM PLANNING	1
QUALITY ASSURANCE	3
REALISM/RISKS	1
RESOURCES	1
SCHEDULING & CONTROL PROCEDURE	1
SOFTWARE DEVELOPMENT TOOLS	1
SOFTWARE MANAGEMENT APPROACH	1
SOFTWARE MANAGEMENT TOOLS	1
SOFTWARE PERSONNEL RESOURCES	1
SUBCONTRACT ARRANGEMENTS	1
SUBCONTRACTING	1
SUBCONTRACTOR/MATERIAL MANAGEM	1
TOTAL MANAGEMENT APPROACH	1
UNDERSTAND POTENTIAL PROBLEMS	1

<u>Area</u>: SCHEDULE

Item	Usage
ABILITY TO MEET SCHEDULE	1
COMPLETENESS & REALISM	1
CONFIGURATION & DATA MANAGEMEN	1

Item	Usage
INTEGRATION WITH LATER PHASES	1
ORGANIZATION STRUCTURE	2
PERSONNEL	1
PLANNING	2
PRODUCTION PLANNING	1

<u>Area</u>: TECHNICAL

Item	Usage
AEROMECHANICS	1
AIR CONDITIONER CART	1
AIR FORCE REVIEW	1
AIR VEHICLE DEVELOPMENT	1
AIRCRAFT INSTALLATION	1
AIRCRAFT INSTALLATION CONSIDER	1
AIRCRAFT INTEGRATION/INTERFACE	2
AIRCRAFT INTERFACES	2
AIRCRAFT STRUCTURAL INTEGRITY	1
AIRFRAME	2
AVIONICS INTEGRATION	1
BIRD STRIKE	1
CAPABILITY OF SYSTEM	1
CART	1
COMMONALITY	1
COMPLIANCE WITH RFP	14
COMPUTATION SYSTEM	1
COMPUTER PROGRAMS	1
COMPUTER RESOURCES	1
CONCEPTUAL UNDERSTANDING	9
CONFIGURATION DESIGN	1
CONFIGURATION DESIGN FEATURES	1
CONSOLES & DISPLAYS	1
CONTRACTOR PAST PERFORMANCE	2
COST CONSCIOUS APPROACH	1
CREW SYSTEMS	1
D/V TRANSITION TO FULL SCALE D	1
DATA BASE MANAGEMENT SYSTEM	1
DATA PROCESSING HARDWARE	1
DEGREE OF RISK	1
DESIGN	12
DESIGN APPROACH	2
DESIGN CONCEPT	2
DESIGN REQUIREMENTS	1
DOCUMENTATION	1
DURABILITY	1
EASE OF MODIFICATION	1
EMULATION/SIMULATION SUBSYSTEM	1
ENGINE	1
ENGINEERING CAPABILITY	1

Item	Usage
EXPERIENCE	3
EXPERIENCE & ORGANIZATION	1
EXPERIENCE & PERSONNEL	1
FLIGHT CONTROLS	1
FLIGHT EQUIPMENT	1
FLIGHT STABILITY & CONTROL	1
FUNCTIONAL PROGRAMS	3
GENERAL KNOWLEDGE	1
GENERATOR CART	1
HARDWARE	1
HARDWARE DESIGN & PERFORMANCE	1
IN-DEPTH KNOWLEDGE	4
INGENUITY & IMAGINATION	1
INTEGRATION	1
INTEGRATION/INTERFACE	1
LANDING GEAR DESIGN	1
MAINTAINABILITY	1
MANUFACTURING CAPABILITY	1
MANUFACTURING DESIGN	1
MANUFACTURING MANAGEMENT	1
MATERIALS/TECHNIQUES/EQUIPMENT	1
MISSILE SYSTEM	1
MOTION SYSTEM	1
OPERABILITY	1
OPERATIONAL TESTING & COMPATIB	1
OPERATIONS METHODOLOGY	1
OPERATIONS/MAINTENANCE REQTS	1
OPTICS	1
ORGANIZATIONAL STRUCTURES	1
OVERALL DESIGN APPROACH	1
PAST EXPERIENCE	1
PAST PERFORMANCE	2
PERFORMANCE	6
PERFORMANCE ASSESSMENT	1
PERFORMANCE VERIFICATION	2
PERSONNEL	4
PHASE I TEST RESULTS	1
PHASE II APPROACH	1
PRODUCTION DESIGN	1
PROPULSION & POWER	1
PROPULSION & VEHICLE POWER	1
PROPULSION INTEGRATION	1
QUALITY ASSURANCE	1
RELIABILITY	1
RELIABILITY & MAINTAINABILITY	2
RESOURCES	1
RESULTS OF FSED CONTRACT	1
RISK	4
SAFETY	1
SHELTERIZATION	1

Item	Usage
SIMPLICITY	1
SIMULATION FIDELITY	1
SOFTWARE	1
SOFTWARE DESIGN & DEVELOPMENT	1
SOUNDNESS OF APPROACH	11
SOUNDNESS OF DESIGN	1
SPECIAL CONSIDERATIONS	1
SPECIAL TECHNICAL FACTORS	2
SPECIFICATION COMPLIANCE	1
SPECIFICATIONS	2
STRUCTURAL DESIGN	1
STRUCTURAL INTEGRITY	2
STRUCTURE & LANDING GEAR DESIG	1
SUBSYSTEM/SYSTEM INTEGRATION	7
SUPPORT EQUIPMENT	1
SUPPORTABILITY	1
SYSTEM CONCEPT	1
SYSTEM DESIGN	2
SYSTEM DESIGN/PERFORMANCE	3
SYSTEM ENGINEERING APPROACH	1
SYSTEM HARDWARE	1
SYSTEM INTEGRATION	1
SYSTEM PERFORMANCE	1
SYSTEM REQUIREMENTS	2
SYSTEM RISK REDUCTION	1
SYSTEM SOFTWARE	1
SYSTEM TECHNICAL PERFORMANCE	1
SYSTEM TEST & EVALUATION	2
SYSTEMS ENGINEERING APPROACH	1
SYSTEMS ENGINEERING MANAGEMENT	5
TECHNICAL APPROACH	7
TECHNICAL DEVELOPMENT	1
TECHNICAL RISK	1
TECHNIQUES & METHODS	1
TECHNOLOGY BASE	1
TEST	1
TEST & EVALUATION	5
TESTING	1
TRADE-OFF EVALUATION	1
TRAINING	1
UNDERSTANDING OF THE PROBLEM	8
USABILITY	1
VISUAL SYSTEM	1
WEAPON INTERFACES	1
WEARLIFE	1
WORK CONTROLS	1

Area: TECHNICAL/OPERATIONS

Item	Usage
AIR VEHICLE	2
AIRCREW ACCOMMODATIONS	1
AVIONICS	3
CABIN CONFIGURATION	1
CARGO COMPARTMENT	1
COCKPIT CONFIGURATION	1
COMMONALITY	1
COMPUTATIONAL SYSTEM	1
DESIGN QUALITY	1
ENGINEERING SPECIALITIES	1
FLIGHT STATION	1
INFLIGHT PERFORMANCE	1
OPERATIONAL CAPABILITY	1
QUALIFICATION TESTING	1
RELIABILITY & MAINTAINABILITY	1
SPECIAL MISSION EQUIPMENT	1
STUDENT STATION/INSTRUCTIONAL	1
TEST & EVALUATION	1
UNDERSTANDING OF THE PROBLEM	1
USABILITY	1
VISUAL SYSTEMROACH	1

Area: TECHNICAL/PRODUCTION

Item	Usage
FACILITIES	1
PERSONNEL	1
PRODUCTION PLANNING	1
QUALITY ASSURANCE	1

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His subsequent career has included pilot training, and tours of duty flying C130s, basic flying instruction at Point Cook and on loan to the Royal Malaysian Air Force at Alor Setar, Malaysia, and advanced flying instruction on C130s. His last assignment prior to entering the School of Systems and Logistics, U.S. Air Force Institute of Technology in June 1983, was as Training Flight Commander, No. 37 Squadron, RAAF Richmond, Australia.

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An exploratory research which aimed to determine the feasibility of creating a decision support system to aid the program manager in determining the evaluation criteria to be used in ~~a~~ Source Selection. The topic was approached in general terms with a review of the DOD and USAF regulations and other literature pertaining to source selection evaluation criteria, and also a brief review of decision making processes and a decision support system framework. A dataset of 81 previous source selection plans from Air Force Systems Command, Aeronautical Systems Division was examined with the aid of a commercially available microcomputer based database management system to see whether previous experience of selection of evaluation criteria could be incorporated into a DSS. A heuristic methodology was developed which can provide an indication to the program manager of the criteria areas he should consider for use in his source selection, based on the historical data. It involves describing the system under procurement in terms of specific attributes of the system, and using the associations observed between those attributes and criteria within the historical dataset to predict the likely criteria for the new system. The research presented only the general basis for a DSS and further research is required to establish the validity of the methodology and implement a DSS in any particular operational situation.